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PONTOON BRIDGES.

WITH the aid of the accompanying engravings, from sketches by Mr. Comba, our readers will be able to understand how a bridge of boats is constructed on a campaign.

FIG. 1.

First, as to the location: any spot selected at random will not answer. The staff officer selects the place in advance, and this must always be between two bends (Fig. 1). Localities where the water foams or exhibits eddies must be avoided. Eddies indicate a great depth, and undercurrents that would increase the difficulty of maneuvering and affect the stability of the bridge. Foam usually indicates reefs.

FIG. 2.

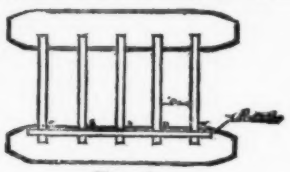


FIG. 3.

There are two kinds of bridges—floating and stationary. The kind here under consideration is a combination of the two. Such or such a combination is employed according to the number of boats at hand or to the quantity of utilizable material *in situ*. The flooring of the bridge is supported by balks resting upon the edges of the boat (Fig. 2). These balks are five in number for each pair of boats (Fig. 3). After this, ropes are passed over the balks and made fast to them, in order to hold them in place.

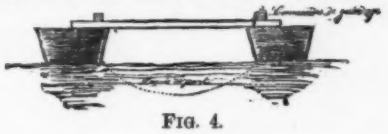


FIG. 4.

The first span is called the shore bay (Fig. 4). A load does not weigh solely upon the bay over which it is passing, but upon the whole bridge thus rendered rigid (Fig. 5). Each boat is held in position in the watercourse by means of an anchor provided with a stock (Fig. 6). The role of the latter is to cause the anchor to catch. In the absence of anchors, millstones or harrows are used. The flooring is connected with the banks through the intermedium of trestles (Figs. 7 and 8).—*Le Monde Illustre.*

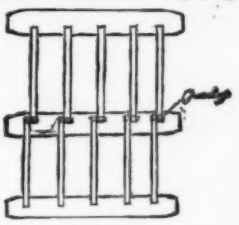


FIG. 5.

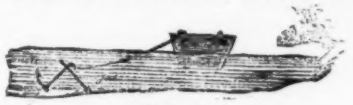


FIG. 6.

[Continued from SUPPLEMENT No. 624, p. 9961.]

IRRIGATING MACHINERY ON THE PACIFIC COAST.*

By Mr. JOHN RICHARDS, of San Francisco.

Balanced Pump with Single Lateral Inlet.—The construction adopted by the author for pumps with a single inlet at one side is of a form most suitable for the requirements of the Pacific coast, and essential in many cases.

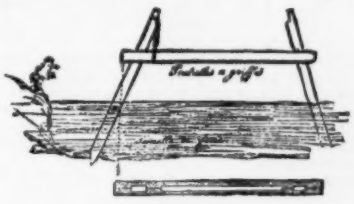


FIG. 7.

The pump is of 13 inches bore arranged for a head of 30 feet. The wheel consists of a curved disk, shaped so as to deflect the water gradually from the center to the circumference. On the face of the disk are formed vanes of unequal area. On the back of the disk are also vanes. Holes are made through the disk, so that any water passing around the circumference may circulate in this way. An equal or nearly equal centrifugal action is

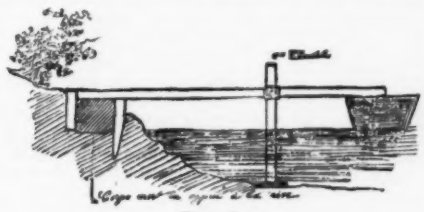
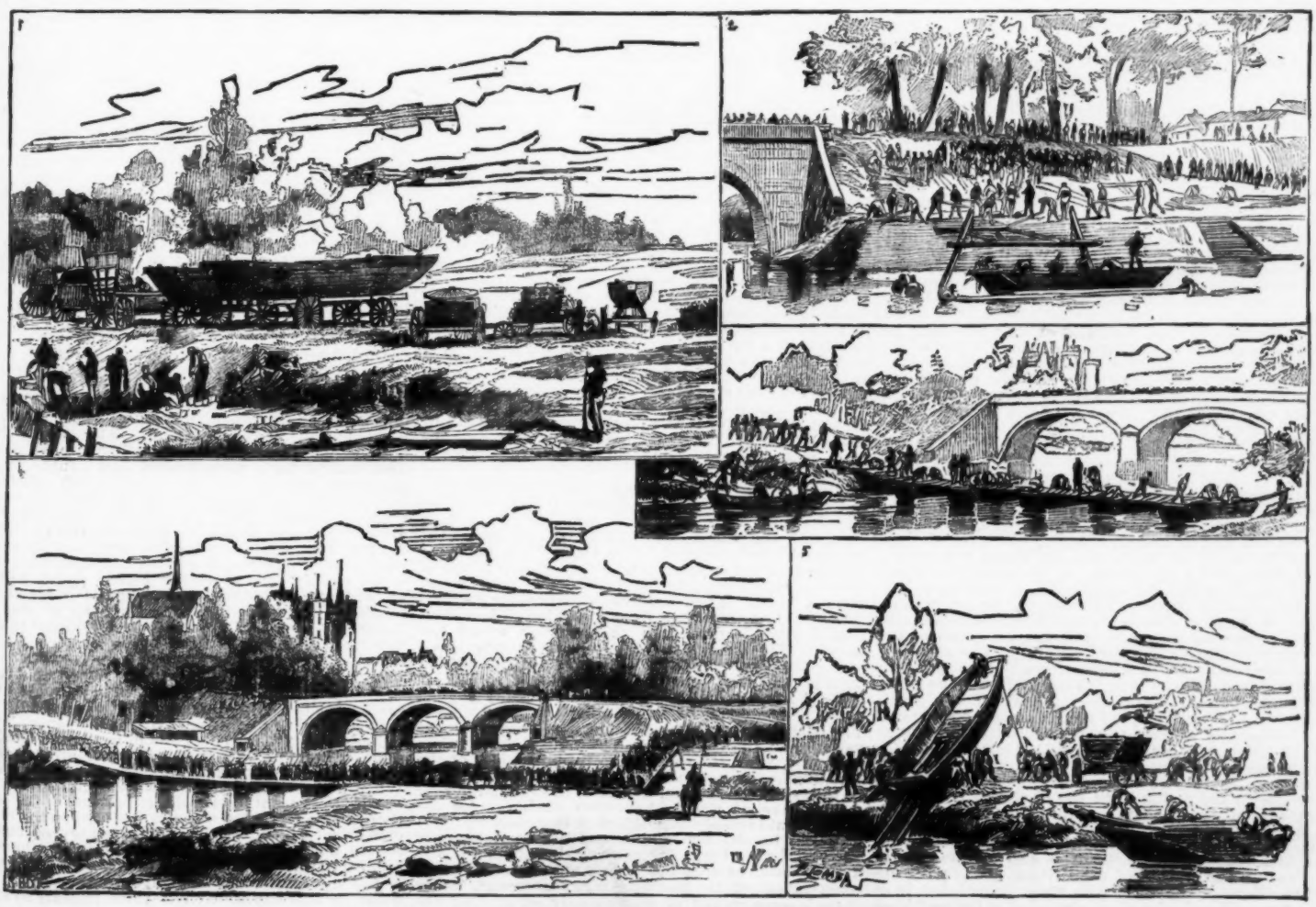


FIG. 8.

* A paper recently read before the Institution of Mechanical Engineers, London.



MODE OF CONSTRUCTING PONTOON BRIDGES.

thus set up on each side of the disk, and there is no axial thrust, the pump being balanced in the same way as though there were double inlets, one at each side. In this arrangement the suction pipe is easily removed, and can be hoisted vertically clear of the pump. The water passages are also more free, and of large area until the disk is reached. In order to guard the spindle bearings from sand and grit, the packing is placed inside the main bearings, which act also as glands for compressing the packing. This arrangement is now employed in all the various modifications of centrifugal pumps from the author's designs, and in working permits no leak of either air or water, and the packing seldom needs renewal.

The pumps are characterized by great steadiness of running, and an absence of the pulsation or jar common with free or open vanes or with inclosed disks. Such jar is often caused by an obtuse or imperfectly formed throat piece, especially with inclosed disks, the radial flow being interrupted at that point.

A matter perhaps of some interest is the method employed of giving the proportions for different sizes of pumps of this class. It is applicable also to various other kinds of mechanical engineering work. The dimensions of all the various parts are arranged in a table, which includes one class of pumps from 2 inches to 30 inches; and this table takes the place of drawings for each size, especially in constructing patterns. In the present instance the table gives eighty dimensions for each of nine different sizes of pump. The several dimensions cannot be assumed from graduated scales, but must be the result of accurate drawings for nearly all sizes. This plan has been applied to various kinds of work in the author's practice, and is believed to be of great value in any case where system and uniformity are possible. The dimensions can be easily changed for special machines, and determined by approximation, without the usual difficulty of working out a wholly new design.

Pit Pumps.—The common arrangement of what are called pit pumps in California is as follows. When the water rises in the wells within suction distance of the surface, horizontal pumps are employed; but when this distance exceeds 20 feet, rectangular pits are sunk, from 10 to 60 feet deep. Two or more tube wells are sunk from 50 to 150 feet below the bottom of the pit, and in these are inserted the suction pipes leading to the suction box on which the pump is mounted. The driving shaft is supported in thrust boxes, and, when of several lengths, is connected by clamp couplings, the bolt passing through the ends of the shaft, so that the couplings may not drop down if they should come loose. The pump being balanced, there is no thrust except that caused by the weight of the spindle and wheel. This is taken up in the thrust box, which has an annular oil chamber, and collars that perform the double office of supporting the spindle and sealing the joint to prevent the entrance of air, thus taking the place of the common packing gland. The valve is so arranged that when open it will stand clear of the water current, as indicated by the dotted lines; otherwise the facing is soon cut away by the sand and gravel, which act like the sand blast. Foot valves cannot be employed in the suction pipes, because in most cases there is no room in wells for a case large enough to allow of the valve opening fully. The valve seat is raised to avoid the valve being fouled with gravel. The external case is made rectangular in plan, with the twofold object of giving it elasticity, so that it shall not be broken by water shock in stopping, if the cushion should fail, and also of allowing the valve to open fully.

The uptake pipe is usually made of sheet iron coated with zinc and soldered at all joints. The area of these pipes is an important matter, and does not seem to conform with the usual rules and computations respecting resistance. It is found expedient to have their area at least four times that of the pump discharge, when the head exceeds 50 feet. A charging pipe is carried up to the surface, where an air pump or steam ejector is employed to exhaust the air and fill the pump. Among the principal objects aimed at in the present pumps are—the greatest possible simplicity; easy separation into parts, so that the machinery can be raised out of the pits or lowered into them without tackle; access to all interior parts; and the highest efficiency possible under the circumstances. The circumferential speed of the pump wheels in feet per minute being approximately 500 times the square root of the head in feet, wheels of 24 to 30 inches diameter can be used for heads up to 100 feet without the speed of the shafts exceeding the rules of safe practice. In 1884 the author designed compound or double wheel pumps for use in pits, two wheels being employed, as proposed many years ago by Mr. Gwynne and also by Continental makers; but with the difference that the water was drawn into the top of the pump and discharged from the bottom.

The wheels being unbalanced, and subject to a thrust equal to the area of their inlet multiplied by the head, by inverting the pump this force was employed to support the weight of the revolving parts. This seemed a good method of evading the thrust; but the least change of speed destroyed the equilibrium, so that the thrust was first up and then down; moreover, the upward thrust did not begin until the pump was acting, and consequently in starting, or in case of the pump drawing gas so that the water failed, the whole weight of the running parts was thrown on the pump bearings. A number of these pumps have been made, and have performed very well, with the exception of the above difficulties and a low efficiency. The efficiency was reduced by the discharge from the wheels being radial and the impact being of course lost. The effect of the mechanical push of the vanes is no doubt greatest when the relative speed of the vanes and water is approximately as two to one; and it diminishes as these speeds vary, or as the head. This indicates for high heads the expediency of a contracted volute or casing, so as to give the water as great a velocity as possible in the casing until the discharge is reached. Some recent experiments confirm this view.

A horizontal pump for shallow pits was designed by the author in 1884, and applied in a number of cases for lifts from 30 to 50 feet. It is also an example of balancing the weight of the driving shaft by the upward thrust of the wheel, the water being taken in at the top. The wheel is of the shrouded or inclosed kind with six vanes, discharging into a volute casing. These pumps were arranged without a packing gland for the spindle; but the irregularity of the upward thrust and the consequent lifting of the shaft prevented effective sealing by the thrust collars. A difficulty sometimes experienced with these pumps receiving the water at the top is the accumulation of carbonic acid gas given off by the artesian well water, especially from deep wells.

Low Lift Centrifugal Pumps for Land Reclamation and Irrigation.—As the Sacramento and San Joaquin rivers approach the ocean, the sedimentary plains bordering upon them sink below the level of the winter and spring floods, and hundreds of square miles become covered with water from 1 foot to 10 feet deep. These plains are called tule lands, from a kind of soft reed of that name which covers the whole surface where water stands. When drained of water and cleared of the tule growth, the soil is a bed of vegetable compost of such surprising fertility and strength that crop after crop can be grown in the same year.

It is mainly on these tule lands that are produced those prodigious crops of wheat, barley, potatoes, etc., which have rendered California famous in agriculture. These fertile lands, lying near San Francisco, and reached by water, rail, and roads, are of great value, and their reclamation has been the object of costly and extensive efforts. The work has been attended with great difficulty, and the larger part of the area once drained has subsequently been lost again, in consequence of the fluctuations of the rivers being so uncertain, and the period of exact observation having not yet been long enough for determining the levels of high floods. Moreover, placer mining has sent down silt enough to change nearly all the levels during the past twenty years.

The embankments, when made of peat, have not weight enough to resist the pressure of the water; and being buoyant, are sometimes floated away bodily. They are so porous that the percolation is enough to require pumping machinery in most cases; besides which, the rainfall in winter and spring has to be pumped out when the rivers are higher than the lands. The uncertainty as to the quantity of water to be raised, the absence of permanent foundations, and the speculative nature of the attempts to reclaim the land, require machinery not merely of a cheaper kind than elsewhere, but also of quite a different character from that employed in other parts of the world, where land drainage is mostly performed at central pumping stations constructed for a definite and permanent duty.

The tule lands are divided into districts, for each of which there is an engineer by whom all plans and estimates for pumping machinery are closely examined; and a guarantee of efficiency is required. Besides the reclamation of the tule lands, there is also the nearly analogous duty of pumping from rivers to irrigate what are called the bench lands, lying from 15 to 30 feet above the water level. The limit of the height to which water can profitably be raised by machinery for ordinary crops at the present price of fuel and cost of machinery may be set down at 25 to 35 feet. Most of the pumps now in use are of small size, such as may be driven by thrashing engines of 25 to 35 indicated horse power, and are of the types already described.

A reclamation pump of the usual construction is mounted on a framing made of Oregon pine. This is a hard, stiff kind of timber, almost as strong as ash, straight grained and without knots, of which beams can readily be obtained 50 feet long and 24 by 12 inches section. For the smaller pumps, iron bed plates are employed, and also for the larger, wherever the extra cost is not objected to; but the timber frames answer very well, provided the machinery is so arranged that its working shall not be interfered with by such flexure as the timber framing is liable to. The centrifugal pump is arranged with its spindle horizontal; and in order to avoid end thrust the wheel is made with open vanes. The interior of the casing is turned smooth; and the wheel is also carefully turned after having been fixed on its spindle. The engine has two single-acting cylinders, of which the diamater is usually equal to two-thirds that of the discharge pipe from the pump, when the total lift is not to exceed 29 feet. The driving shaft is of steel, and is connected with the engine by a compression coupling, the same as previously described. The bearing next the pump is mounted on a planed iron seating, so that it can be slid back when the pump gland requires packing. By thus supporting the driving shaft close up to the pump, no bearing is required on the suction side of the pump, which would be objectionable on account of the obstruction it would offer to tule roots, weeds, straw, and other rubbish that finds its way into the pump. All the parts have to be arranged for allowing of ready access to the interior of the pump and pipes. The suction pipe is slung by a chain, so that it can be lifted away from the pump in case of the foot valve becoming choked. The inlet nozzle of the pump casing can be cleared from ordinary obstructions by removing the hand plate. The two side plates of the pump casing are easily removed.

Whenever the wheel becomes clogged with tule roots, the suction pipe and the plate on the same side are loosened and swung aside; the coupling is also loosened, and the wheel can then be drawn out at the suction side to be cleared. The time of the whole operation need not exceed ten minutes. The pump is of a semi-portable character, and adapted to most cases, but not to all. When the head varies on the delivery side, as it does sometimes, from 1 to 14 feet, it is evident that a pump arranged in this manner would not answer. The pump and engine must, of course, stand above the water level, which varies both inside and outside the embankment.

There is no means of working economically against a low head, except by submerging the pump wheels. The height of the suction lift must be more than the variation of the water inside the embankment. Consequently, when the water is low on both sides of the embankment, as much as two-thirds of the work may be lost, since the siphon action of the discharge pipe cannot be relied upon. A bottom discharge for the pump would remedy this difficulty in a measure; but it would involve the addition of an air tight sluice valve in the discharge for starting the pump, and also a pneumatic or steam charging apparatus. The siphon action of the discharge pipe soon ceases, unless there is some means of continuously exhausting the air given off by the agitation of the water in the pump. To connect the discharge pipe with a condenser, or to employ other means of exhausting the liberated air, introduces a complication not compatible with the attendance commonly received by such pumps on the Pacific coast.

Submerged Pumps.—A vertical pump of the Whitelaw type, of which several have been constructed on the Pacific coast from the writer's designs, is one of the cheapest arrangements, and places the machinery well above the water, excepting only the pump wheel, which is submerged. The engine and boiler are placed on the top of an embankment, and are generally raised 1 foot to 2 feet above the ground; the embankment itself is in most cases wide enough for a roadway on the top, whereby fuel can be hauled or access obtained to the works when the whole country is flooded. The pump casing is a vertical cylinder, having a suction nozzle at the bottom and a flange at the top, by which it can be suspended from the bottom of the trough. The pump spindle is supported in three bearings, and is driven by a band from the engine. A pair of bevel wheels are sometimes employed at the top of the spindle, so as to avoid twisting the band. The wheel or runner is curved upward, so that the tips of the vanes terminate parallel with the sides of the pump casing. Inside the casing is inserted a central sheet iron cone; and the current of discharge water, ascending through the widening annular space between the cone and the cylindrical casing, loses its velocity gradually as the area of passage enlarges; while at the same time the whirling motion with which it quitted the wheel is checked by means of curved blades fixed on the outside of the cone, whereby the current is deflected upward. Since centrifugal force acts at right angles to the axis of rotation, it is evident that the water has to undergo deflection through one more right angle in a pump of this kind, with curved runner discharging parallel to the axis, than when the discharge is at right angles to the axis. But although the efficiency may thereby be impaired to the extent of as much as 10 per cent., this is often of less importance than the countervailing advantages gained with submerged pumps. There is no charging to be done, no valves, and no pipes. Tule roots and other obstructions pass freely through the runner, and are thrown out against the pump casing, where they are soon worn away. A pump for raising 400,000 gallons an hour has a cylindrical casing 40 inches in diameter, and an engine capable of developing 35 horse power. Similar pumps have been erected on the San Joaquin and the Colorado river, and have raised 660,000 gallons an hour. Nearly forty years ago Mr. Whitelaw's experiments at Johnstone, near Glasgow, demonstrated that a high efficiency could be attained with pumps arranged in this manner. The only impediment is in utilizing the energy of the water after it leaves the wheel. If the velocity is destroyed by impinging against the body of water in the uptake, the efficiency for low heads will not exceed 40 per cent. The pump was much improved by inserting above the wheel a cone having curved deflecting blades, which changed the motion of the water from a horizontal to a vertical direction. With careful attention to the various conditions accompanying the action of centrifugal pumps, this arrangement has much to recommend it, especially in economy of first cost. In the Louisiana district about the mouth of the Mississippi river, pumps of this kind are extensively employed for low lifts, the action being analogous to that of a turbine water wheel inverted, and centrifugal effect being almost disregarded.

Bulkhead Pumps.—In this system, a pair of centrifugal pumps are arranged for driving the water through a bulkhead against a head varying from nothing to 10 feet. The pumps are submerged to a sufficient depth to require no charging, and, consequently, no valves are necessary. The area of the two discharge nozzles is 150 square inches each, and the quantity of water delivered is 500,000 to 800,000 gallons an hour. This arrangement is the least expensive that can be adopted for land drainage or irrigation. It was suggested by a Dutch engineer who had erected similar works in Java, and has been found in every way satisfactory. The embankment is cut through, and a strong timber bulkhead is erected across the gap. The pumps are placed immediately behind the bulkhead, with their discharge nozzles projecting through it. Flap valves opening outward are hung over the discharge nozzles to prevent back flow through the pumps when not working; in dry seasons they are sometimes opened for letting water flow through for irrigation. The vertical pump spindles are driven by bevel gearing from a horizontal shaft. The engine is single-acting, with two cylinders of 10 inches diameter, and its speed is 300 revolutions per minute. Machinery of this description was erected during 1885 on the Sacramento river, 75 miles from San Francisco, for draining tule lands.

Pumps Driven by Bands.—An arrangement for raising 900,000 gallons an hour is by means of two centrifugal pumps driven by bands. The two discharge nozzles from the pumps are each 115 square inches area. The pumps have open wheels, and double suction pipes, one on each side, not joined; each pipe has a foot valve of 100 square inches area. The suction pipes themselves serve as the supports for the pumps, being made strong and with large flanges to rest on the timber framing. The sump is 6 feet deep, and the suction pipes dip into it to different depths, so that when the water supply falls short the higher pump will run empty or be disconnected, leaving the lower only to continue working. The average head in this case being only from 3 to 5 feet, it was considered that the water could be driven more by direct push than by centrifugal force. The pumps were constructed accordingly with smooth iron vanes, bolted to a square extension on the pump spindle. The throats of the suction inlets were made very sharp, and brought in as close as possible to the inner tips of the vanes. In the writer's opinion the effect would have been much the same, or perhaps even better, if the volute casing had been replaced by the ordinary concentric casing. When a good turbine water wheel will realize a duty of 70 to 80 per cent. by the direct pressure of the water, there seems no reason why a centrifugal pump, considered as a turbine wheel acting in the reverse manner, should not utilize in some near proportion the power applied to it for moving and raising water. The writer is not aware whether any investigations have been made in this direction; but there appears to him to be a close analogy between the two cases, at least for low heads. The discharge pipe carried through the

embankment is 30 inches bore, and is set with slope enough to let the water run down it from the pumps when the head at the discharge outlet is not too high. The engine is placed level with the top of the embankment, 15 feet above the pump floor. The whole of the machinery is mounted on wooden framing, being on treacherous ground. It was erected during the winter, when no other foundation was possible, and gives promise of standing well. Movement takes place, the whole structure sometimes going together, but excellent service has been done. The work was planned and its erection superintended by Mr. J. P. Van Loben-Sels, a gentleman well acquainted with drainage works in Holland, and of considerable experience in such engineering matters. It drains the leakage and rainfall from 8,000 acres of land, surrounded by embankments 15 miles long; the estate is on the Sacramento river, and is one of the best maintained in the valley. The embankments are of a superior character, being for the most part made of clay or loaded with clay; they sink, however, and have continually to be raised and strengthened. This plant has since been increased to a capacity of 2,400,000 gallons an hour, by the addition of a pump of 30 inches bore, driven by a compound condensing engine.

Single-acting Engines.—For pumps directly geared to engines, the practice differs somewhat from that of English makers; but is much in advance of the methods employed in the Eastern States, unless it be in the case of one firm there, who have copied Messrs. Gwynne's pumps, and drive them with pairs of single-acting engines; of these, however, present knowledge will not permit comparison. The author at first employed single-acting engines. These are especially suited for driving centrifugal pumps where permanent foundations are wanting. Being wholly self-contained, working at high speed with reasonable economy, and occupying but little space, they bid fair to take the place of double-acting engines for the purpose. As the thrust on the connections and bearings is in one direction only, there is no compensation to look after, and no shake or knock. There are no glands to pack, and scarcely any oiling to do. The valves are of the oscillating cylindrical kind, the steam entering round the outside of the valve, and exhausting through its interior. The connecting rods are of brass, made as light as possible. The crank shaft is of steel, with cranks opposite, and with counterbalances bolted on. The valve gear is of the simplest construction, consisting merely of an overhung crank and connecting link. The eccentricity of the crank can be readily adjusted for regulating the lead of the valve, or reversed for running the other way. Automatic gear for controlling the speed by the cut-off is sometimes applied; but for regular duty, like pumping, the throttle valve adjusted by hand is quite as good, and is better understood by attendants. The crank chamber is partially filled with a bath of water and oil, which is splashed by the cranks into all the bearings and also into the cylinders. No other oiling is required, except of the valve link, which is made hollow, so as to be oiled at both ends while in motion. The cylinders are surrounded by a rectangular casing which serves as an air jacket, so that but little heat is lost by radiation. The objections to this class of engines are their dimensions in the direction of the crank shaft, a want of steam economy, and the low duty consequent upon the compression at the top of the upstroke required to keep the bearings in contact and to avoid knocking. The difficulties that have been met with during the past ten or twelve years in maturing these single-acting engines are considered by the writer to lie not in the principle or mode of working, but in providing a suitable connection for transmitting the power from the pistons to the cranks on the driving shaft.

Differential or Compound Engines.—In later practice the engines adopted are of the differential or compound type. The steam is admitted first into the annular space sarrounding the trunk, and after acting in the upstroke underneath the piston is expanded upon the top in the downstroke, acting then on the difference of area between the two sides of the piston, and expanding three times or more. The engines are made without stuffing boxes except for the valve stems; and oiling is performed by inclosing the parts as in the single-acting engines. In this way a good expansion is attained with a single and simple slide valve; and the engine is reduced to the fewest and simplest parts possible.

Hydraulic Rams.—Owing to the extensive use of small hydraulic rams on the Pacific coast, some experiments were commenced at the beginning of this year by the author in conjunction with Messrs. W. T. Garratt & Co., engineers, of San Francisco, in order to see whether larger machines of the kind could be constructed for meeting the requirements of raising water from the mountain streams. As yet these experiments are by no means completed; but the author believes some of the constructive features are of sufficient interest to warrant their being appended to the present paper. The various phenomena that arise in employing the impact of water in hydraulic rams are such as to render the matter one of experiment, unless in cases where the intermissions or valve movements are controlled by independent machinery, that is, by some power independent of the flow or issue of the water passing through the ram. The latter is unquestionably the correct method, if the supplemental mechanism can be made durable and reliable, as no doubt it can. The first experiments made were with small rams having inlet pipes from 2 to 3 inches diameter. The two valves being nearly balanced, the difference of their areas constitutes the measure of the upward or closing force, which is of course much less than in these of a single valve. The valves fall by their weight in the usual manner, and are raised partly by the stream rushing out round the upper valve, but mainly by the upward pressure of the issuing current against a curved shield fixed on the valve stem. In working it was found that accurate adjustment was required to suit the head or fall of the driving water, and also that the shock was too great for the safety of large rams. The method was therefore changed to one in which the two escape valves are arranged to pass up freely through their seats, and are stopped by an air cushion at the top. The waste water nearly all escapes at the upper valve, small outlets only being provided in the lower valve, for permitting sand to escape if any should be carried into the machine. The closing is effected, as before, mainly by the upward pressure of the issuing stream against the curved shield. When the valves are shot upward in closing, the shield enters the air chamber above it, in which it fits as a piston, and the momentum is thereby checked without the least shock. An air cock is inserted in the top of the air chamber for regulating the amount of resistance offered by the air cushion. Additional weight, if required, is added on the top of the valve stem; it is found, however, that the higher the head, the less is the weight required for opening the valves. Snifting valves were at first applied, but seemed unnecessary. Rams arranged in this manner work without noise or jar and give a high efficiency for forcing four to five times the height of the propelling head, and are suitable in most cases for irrigating purposes; but when the resistance is increased, the elastic blow or percussive impulse of the current is not enough to raise the check valve against the increased area caused by its lap. In another arrangement of hydraulic ram the escape valve is opened by independent mechanism. The waste escapes at the bottom through four holes. These holes are alternately covered and uncovered by the four wings of the oscillating valve, which is mounted on a spindle. The valve is opened by means of the water wheel and the tappet motion. The two tappets coming in contact at each revolution of the water wheel open the valve to such an extent as may be determined by the adjusting set screw in a slot. As soon as the tappets disengage, the valve is closed by the reaction of the issuing stream against its curved ribs or vanes, the motion being arrested by the tail of the tappet arm. In this manner the motions of the waste valve can be controlled at will, and a greater efficiency attained than with the ordinary method of employing the force of the issuing stream for closing the valve by lifting it. Experiments have not yet been made to determine the most effective motion of the valve with respect to the time of closing, but the indications point to variable requirements in this respect, depending on the resistance offered or the height to which the water is being raised. The action of the machines is smooth and regular when the closing motion is not too abrupt. While unable at present to furnish a more complete description of this class of machines, the author hopes the subject is wide enough to permit of its being again brought before the Institution on a future occasion in a more complete form.

IMPROVED METHODS OF HEATING RAILWAY TRAINS.*

III.—THE SEWALL SYSTEM.

By C. POWELL KARR, C.E., Consulting Architect, New York.

THIS system in its present condition is now in practical and successful operation on the Maine Central Railway. It is claimed that cars have been heated by

FIG. 1.

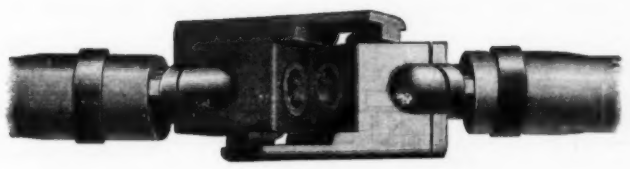


FIG. 2.

FIG. 3.

it, and the temperature within maintained at 70° Fahr. while the thermometer outside registered 40° Fahr. below zero. The system consists of a principal apparatus for ordinary use and an auxiliary external appliance to meet exigencies where steam for heating cannot be secured from the locomotive or other source outside the car to be heated.

In ordinary, every-day use with the train in motion, the steam for the supply of the radiators in the cars comes from the locomotive, and there is no fire in any part of the train except within the locomotive; but in the event of an accident to the train in such a manner that any car is shut off from its supply of steam from the locomotive, or should a car be detached from the train and side-tracked from any cause, or should a car be waiting on a side track for an incoming train to which it is to be attached, then, in any of the foregoing suppositions, reliance for means of heating the car or train is placed upon the auxiliary boiler, which we have styled the secondary appliance. In order to make our explanation of the primary system the clearer, we shall first describe the secondary appliance.

THE SECONDARY APPLIANCE.

The auxiliary boiler consists of a small hot well to receive the drip of condensed water from the pipes, having a small fire box under it, with dumping grate and connected with the piping of the car, so that in case the car is set off at a time and place where heating is necessary and cannot be otherwise obtained, steam can be promptly generated to heat the car until it can be heated by attachment to an engine or stationary heating plant. At the pleasure of the train attendant the grate and the contents of the fire box may be dumped completely, so that not a vestige of fire will remain in the car. The boiler is circular and so economizes space that it does not extend below the axles of the trucks, and a small box under the car contains fuel supply for any reasonable time. If the boiler from which the usual supply of steam is obtained is for any reason cut off or disabled, this auxiliary boiler will maintain the same comfortable temperature with safety until the usual source of supply is restored. The supply of steam from this source is controlled by valves from within the car, that simultaneously act upon each other, so that as the supply from the primary source is turned on the secondary is cut off. The secondary appliance is confessedly an arrangement for a temporary expediency. Its being placed entirely outside the car, so that it would have to be stoked and attended to while the train was at rest, would prevent its practical usage while the train was in motion; and should the rule be rigidly adhered to that the contents of the fire box must be emptied before the train gets under way, there can be no reasonable objection to its adoption as an acceptable addition to the system.

It is claimed that if fire should happen to be contained in the auxiliary boiler while the car is in motion, the four small bolts that support it in case of collision would readily be separated from the car, and its contents be dropped outside and ordinarily left with the trucks where the obstacle was first encountered.

THE PRIMARY APPLIANCES

consist of an arrangement of steam pipes and valves so situated and constructed that perfect control is obtained of the steam admitted into the cars for the purpose of heating them. The steam enters at the forward end of the train, where one valve in each car is so placed that the direction of the current is determined. When desired, steam is admitted in the radiating pipes within the car, placed at convenient points and so distributed to every part of the car where heat is needed, and in any amount within certain limits as required; or the valve can be so placed that any particular car in the train or any number of cars of the train can be "cut off" and no heat furnished, if it is so desired, without in any way hindering the supply for any other car or cars in the train

The principal members of the general arrangement are FIRST, *the couplers;* SECOND, *the system of piping;* THIRD, *the valves;* and FOURTH, *the auxiliary boiler and steam trap.*

THE COUPLINGS.

The success of any system of steam heating appliance for usage on railway trains depends largely upon the mechanical devices by which the natural conditions are to be met and the obstacles removed. One of the most important features of any system is the method of coupling pursued, and in the long run that system will be the most successful which has possession of the best steam coupler. We do not propose to make any comparisons in this article, but desire to study briefly the devices as we find them.

The couplings consist of two similar halves with interlocking arms constructed on the dovetail principle, so that upon coming together they are securely locked by contact. They will withstand any pressure and remain tight until the cars are pulled asunder. Then the bent hose straightens through its own elasticity and the arms are automatically released by horizontal pressure. In Figs. 1, 2, and 3 the coupling is shown in detail.

Fig. 1 represents a side view of the coupling uncoupled. A is a hollow casting of the body in two similar reversed parts to allow the tube, B, to be inserted, and they are fastened by clamps in the steam hose; the gasket, *c*, is rubber, and held firmly by the casting, A. On the tube, B, is cast a flange, D, which is held securely by the two bolts, E E, and the gaskets, C C, in position. The interlocking device consists of grooved projections, F and G, with the tooth, H, and space, I, which engage their corresponding parts on the opposite half. Fig. 2 represents a top view of the coupling in the act of being coupled. Fig. 3 represents a side view of the coupler as coupled between cars. The great motion constantly obtained and imparted from the end of one to the end of the next car is taken care of by the flexible hose, and thus the wearing faces of the couplers are saved from abrasion. The joint is steam tight and guaranteed against leakage by the elastic packing.

*Continued from SUPPLEMENT No. 596, page 9519.

THE SYSTEM OF PIPING.

The system of piping, drainage, and position of parts on a train are shown by Fig. 4, which represents a car with part of a vertical side removed to show the position of the parts, the right hand car being the nearest the source of steam. Live steam is taken from the dome through a common angle valve and passes underneath the flooring of the cab, and under the tender. Its form under the tender is that of a flattened A, with the apex in the center, inclining both ways to facilitate the drainage of such water as may condense from the steam in its onward flow. A rubber hose connection is placed in the piping between the engine and its tender. The steam enters through the coupling, M (see Fig. 4), and

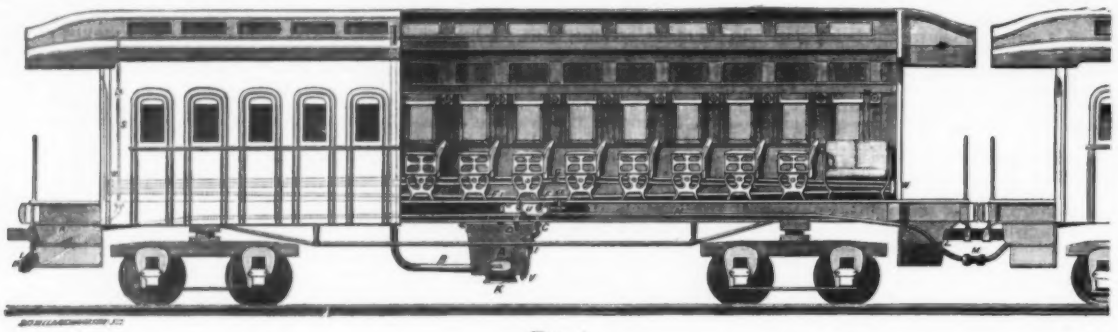


FIG. 4.

the hose, L, through the pipe, H, to the valve, V, and supposing the disk, *a*, to be turned fully open (or with index plate at O), passing through radiating pipe, F, to manifold, W, and so through pipes, G and G, to manifold, W, at rear end of car, and through pipe, F, to center of car, entering valve, V, and passing out through pipe, H, to rear.

Supposing the disk, *a*, to be turned partly open or index plate showing any desired graduation between S and O, any desired amount of steam would pass from pipe, H, to radiating pipes in car. At a proper place in each car a small steam gauge is attached for convenience.

Practical use has demonstrated the fact that cars equipped by this system can be used equally well in the climate of Montreal or New Orleans, and this result is due solely and simply to the mechanism of the device called the controlling valve.

The valve which is principally the one now used, instead of the original three-way valve, is provided with a lower piston which can be set for the purpose of permitting the steam to escape through the valve itself when a car becomes the rear car of the train, and does away with the necessity of cutting a hole in the roof for the admission of an escape pipe, as we have illustrated under Fig. 4. The main valve is the same in every respect of construction and operation, the lower piston being the substitute for the rear escape pipe.

THE CONTROLLING VALVE.

This valve is placed under the floor of each car near its center, and *operated by a key* inserted in a disk set

SIDE VIEW, BROKEN TO SHOW SECTION THROUGH C C.

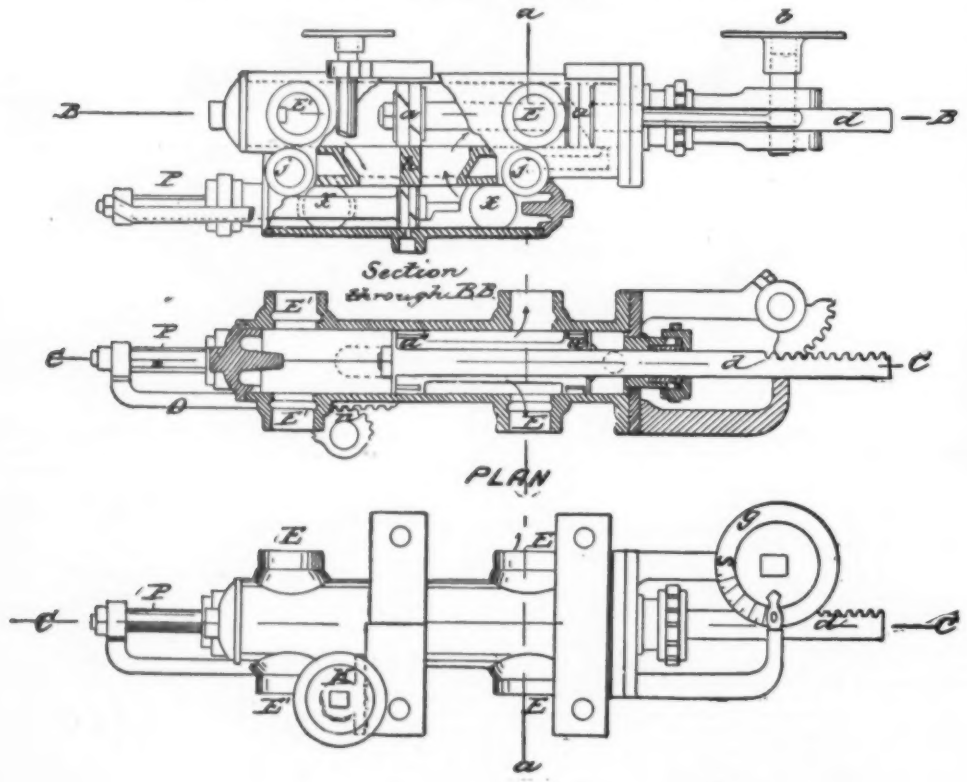


FIG. 5.

in the floor of the car above the valve stem, V. A quarter turn of this key makes all the changes required by this system to control the heat in the cars, and by its proper use the heat can be kept uniform and supplied to meet any requirements. It can be operated only by the regular train attendant.

In Fig. 5 is shown a side view, a plan, a longitudinal section, and a transverse section of the improved valve. The pistons, *a a'*, are actuated by a key or wrench inserted in the square hole in the index, *b*, by moving the segment, *c*, in connection with the racked piston rod, *d*. The pipes that screw into the tapped holes, *e e e' e'*, convey the steam from the valve to the radiating pipes in the car. With the pistons, *a a'*, in the position shown in the illustration, supposing the source of steam to be at the right hand of cuts, the steam would enter from the main pipe through the tapped hole, X, and pass upward, as shown by arrow, to the radiating pipes in the car going to the forward end of the car, then to the rear end of the car through three pipes along the side of the car under the seats, thence forward to the center of the car through one pipe, entering the valve through *e' e'*, passing downward, as shown by arrows, and into main pipe through *x'*, and so on to the rear of the train. These pistons (*a* and *a'*) are only placed in this position when first admitting steam to radiating pipes, in order to "blow out" the air.

After all the pipes in the car become warm, the index, *b*, is turned to any required position between *o* and *s*, on the index plate, *g*, to give the required amount of heat. In this position of pistons, *a a'*, it will be seen that steam may pass to the radiating pipes by *e e e' e'*, so that it enters as required and where required to supply space made by condensation, and thus moving as required, the greatest economy is secured in its use. The point of index, *b*, can be turned fully to *s* on index plate, *g*, and the pistons, *a* and *a'*, will then be in a position to cut off all communication between the tapped holes, *x x'* and *e e'*, thus shutting off all steam from entering the radiating pipes, but allowing it to pass over the bridge, *h* (piston, *a*, having been moved to the left), from *x* to *x'*, and so to the rear without any obstruction, the water of condensation finding an outlet through the cored passage, *i*, at the right end and through the tapped holes, J J, at both ends of the valve, these being connected together by a three-quarter inch pipe and in connection with a steam trap.

When a car becomes the rear car of the train, the index, K, is turned toward the rear end of the car to a point marked on the index plate, *l*, which moves the small piston, *m*, back toward the rear end of the valve or toward the left of the drawing by the segment and racked rod, *n* and *o*, being connected to the small piston rod, *p*. This cuts off all communication between the rear end of main pipe leading from the tapped hole, *x*, and the balance of the pipes, and compels all condensation to pass out through hole, R, to which a trap is screwed, thereby condensing all the steam in the radiating pipes before delivering it into the atmosphere. Should the source of the steam be from the other end of the train or from the left of the illustration, then the direction of the current would be in the opposite direction from that shown by the arrows. The index plates are screwed to the upper side of the car floor and let in flush, so as not to present an obstacle to walking or sweeping, and may be made as ornamental as useful. The pipes along the sides of the cars are protected by bronze monogram screens or wire netting between seats, giving a finished and neat appearance to the fittings.

The highest portion of the distributing pipes is provided with an inwardly opening check valve to permit air to enter when the steam is shut off, so as to prevent the water of condensation from being retained in the pipes by the atmospheric pressure at the drip passage opening. The ingenuity displayed in devising the drip passages in such a way as to open into the closed circulating pipes instead of directly into the air will be more readily seen when it is remembered that the circulating pipes thus drained into act as flow-offs, and that danger from freezing and stoppage of the controlling valve is thereby greatly lessened. The valve is so constructed and operated that one passage is automatically opened in proportion as the other is closed. The inlet and outlet pipes are so arranged with reference to this distinctive device that the circulation is positive and practically automatic.

It can be seen from the drawings that the safety of the coupler as an interlocking device depends upon a compound dovetail, and whatever wear there may be comes upon curved surfaces, and which, by the principle of tangential arcs, will have a tendency to continuous contact.

In Figs. 6 and 7 are shown half sections of the steam trap in use on this system, and Figs. 8 and 9 transverse sections on the lines as indicated. The trap consists of a composition casting, A, on the under side of which is a small cylinder, B, and beneath this again the arm, C, all forming one piece and screwing into the cast iron shell, D. The hole, E, enters the top of the casting, A, and is threaded for $\frac{3}{8}$" pipe, terminating in a $\frac{1}{4}$" hole, F, where it enters the cylinder, B. A $\frac{1}{4}$ inch hole, G, passes out of the lower side of cylinder, B, and is placed one quarter of an inch to the left of the hole, F.

In the cylinder, B, are placed two pistons, B' and B^2, secured rigidly together and pivoted at H to the bar, I, the lower end of which is pivoted to the arm, *c*, at J.

A round case of thin spun brass, O ($3\frac{5}{8}$" by $\frac{3}{4}$ inside), filled with a fluid that is highly susceptible to changes of temperature, is placed between the bar, I, and arm, *c*, one side being pivoted to the bar, I, at K, the other secured rigidly to the arm, *c*, by a stud, L, and nuts, M M. In operation, suppose the nuts, M M, to be properly adjusted, the water of condensation will enter at E through F and G, and pass out of tap at N. When steam attempts to follow the same course, the case, O, is heated and expands, moving the piston, B', until the hole, G, is covered, and thus shuts out everything.

As the steam inclosed in the shell, D, cools, the case, O, contracts and the port, G, is partially opened, or wholly, as the case may be, to let off condensed water at any temperature that the nuts, M M, may be adjusted for.

The length of the main supply pipe is equal to the total outside length of the car plus the platform lengths on each end of the car. The effective heating length must also include the bends leading to the interior, and from the interior of the car back to the return outlet. The inside diameter of the main is $1\frac{1}{4}$ inches. The radiating pipes are of the same size and follow the wall of the car from end to end, entering and departing through the valve (just described) in the center of the car. The number of these pipes depends upon the location of the country in which the cars are to run. For example: In Maine and Minnesota four pipes on each side of the car are necessary. In an ordinary passenger car there would be about 400 feet of $1\frac{1}{4}$ inch piping. In milder climates less piping is used, but in this system the additional amount of piping will not increase the difficulty of keeping the temperature uniform, as each full length of radiating pipe can be short-circuited and cut off from its adjacent length, and so the circulation can be confined to as few pipes as possible, or the supply of steam can be reduced so as to just maintain the needed temperature. The former system is the most economical, since the greater surface of piping in the latter system at a reduced pressure causes a greater relative condensation on account of the greater surface of distribution; but in very cold weather, or in a very changeable climate, as, for example, the North Atlantic States, the combination of the two, or the latter alone, is extremely desirable,

the factor needed being a greater ratio of radiating surface rather than an increase of steam pressure.

In the original patents expressing the ideas of the Sewall system the intention of passing a U loop under each seat was included in the system of piping, but this was in 1882. The amount of friction which such an arrangement would force the steam to overcome would interfere with the practical working of the system with low pressures for a long train, and it has wisely been abandoned. In the present arrangement its designers have studied to lessen the frictional resistances which were shown to be so formidable in our first article upon this subject (see SCIENTIFIC AMERICAN SUPPLEMENT, April 9), and it is readily admitted that they have done so.

The steam pressure in the cab varies from 5 to 15 lb., and is permitted to enter the cars at from 1 to 5 lb. The former is depended upon to overcome the frictional resistances offered by the angle valves, the bends in the main, the resistance in the couplers, and the loss by convection and radiation, and the latter is the pressure which is determined by the amount of heat required for each car.

In order to prevent all the condensation that is possible, the main pipes are wrapped first with asbestos paper, then hair felt, and the two layers incased with canvas, painted outside. The idea involved in this method is to obtain the advantages of the hair felt without exposing it to the immediate destructive action of steam heat. The interposition of the asbestos admirably effects this purpose, although mineral wool is almost twice as good a non-conductor. Hair felt sometimes takes fire from steam at a high pressure and soon becomes charred, so that too much care cannot be observed in its application.

DRAINAGE

is secured in the mains by their rising from each end of the car to the center. The radiating pipes do the same and drain to the steam trap, of which we show sectional views, Figs. 6, 7, 8, and 9. This is a thermostatic device, which delivers the water of condensation and closes against steam, the difference between the temperature of the steam and the condensed water operating it.

In conclusion the writer desires to add that a careful study of the various schemes of steam heating has convinced him that this system represents the highest state of the art of car heating so far practically tested and developed. It is the combined invention of J. H. & D. D. Sewall, of Portland, Me., and its present development has been reached by a constant study and improvement of its action from day to day during the last five years, in which it has been in constant use.

[Continued from SUPPLEMENT, No. 624, page 9966.]

SIBLEY COLLEGE LECTURES.—1887–88.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

I.—THE GENERATION OF STEAM.

By GEORGE H. BABCOCK, of N. Y. City.

Figs. 8 and 9 show a furnace for burning green bagasse, which is the refuse of sugar cane after the juice has been expressed between rollers. This is somewhat similar to the furnace for burning sawdust, excepting the oven is much higher and larger. It is provided with no grate bars, and the air is supplied by a blast, which blast is heated by the waste gases. A number of these furnaces are in use in Louisiana, taking the bagasse directly from the mill and giving remarkable results when we consider that from two-thirds to three-fourths of the weight of the fuel is water.

Fig. 10 is a furnace for burning the waste gases from blast furnaces. The gas is conveyed by an underground flue, shown at the left, through a burner, where it is mixed with the air requisite for combustion. It is necessary in a furnace for this purpose that a small coal fire be kept burning for the purpose of lighting the gas if it should become extinguished by any cause,

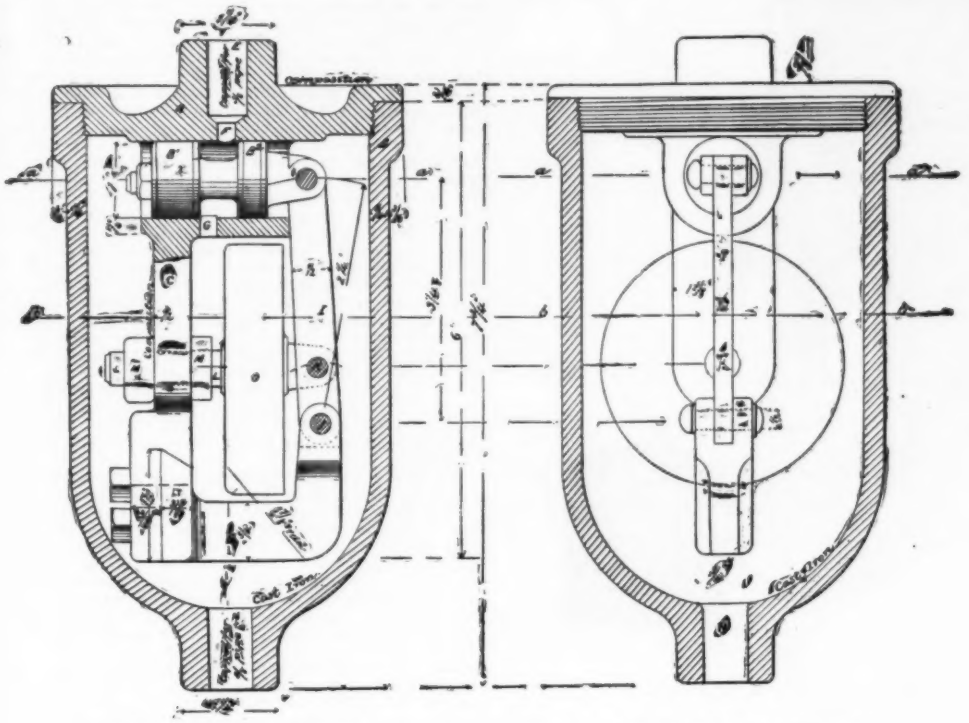


FIG. 6.—HALF SECTION.

FIG. 7.—HALF SECTION.

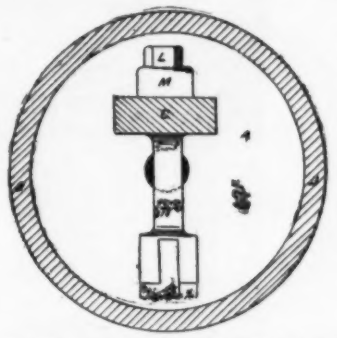


FIG. 8.—TRANSVERSE SECTION AT *b b b b*.

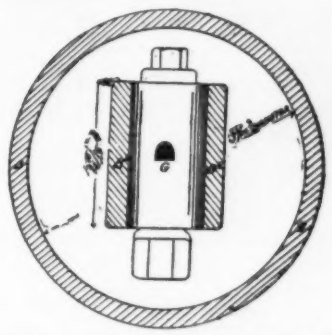
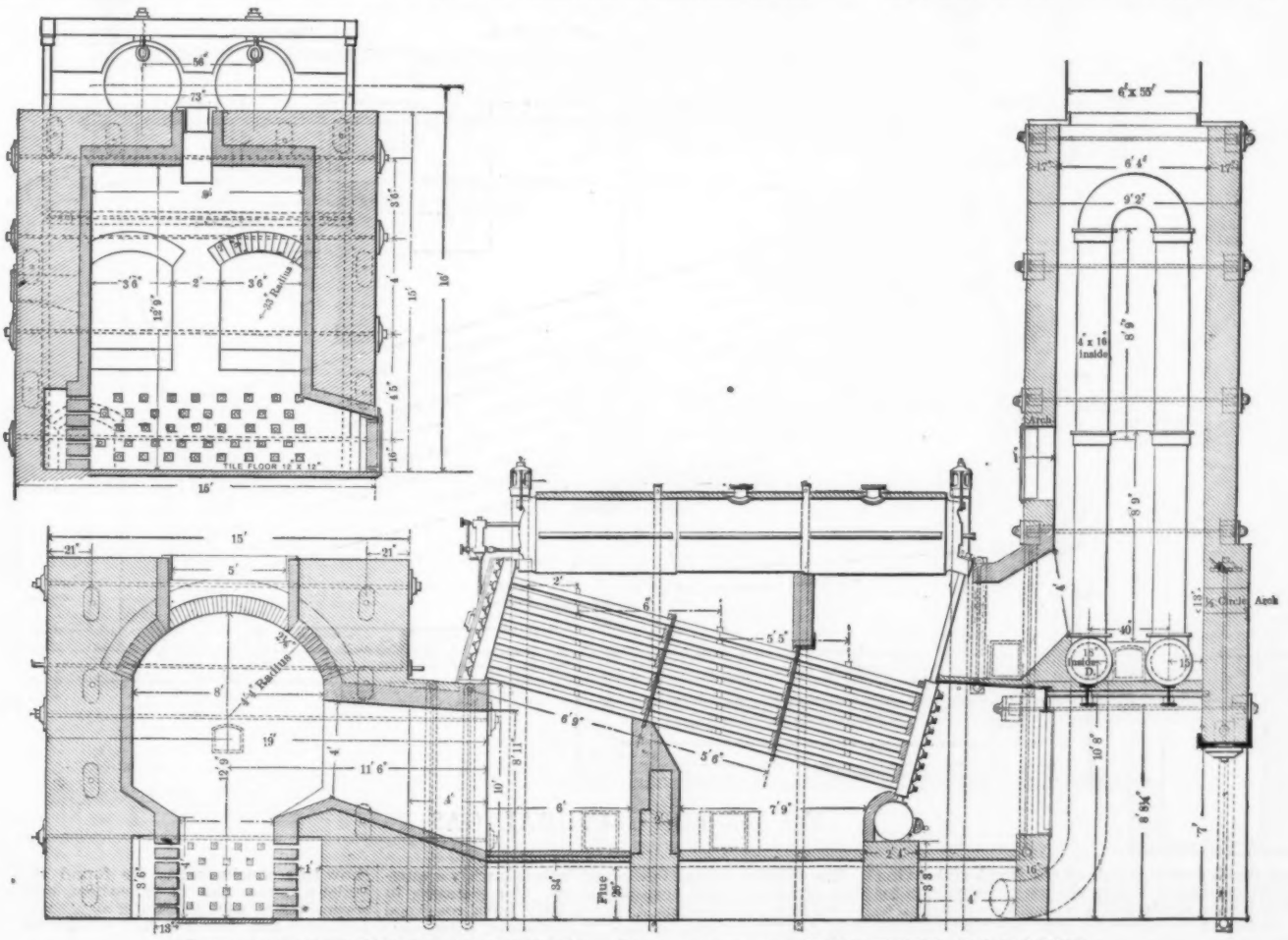


FIG. 9.—TRANSVERSE SECTION AT *a a a a*.



THE GENERATION OF STEAM.—FIGS. 8 AND 9.—FOR WET BAGASSE.

as otherwise a serious explosion might occur within the flue. This figure represents the furnace used in many of the large blast furnaces of the country.

Figs. 11 and 12 show a furnace for burning natural gas, in use by the National Tube Works Company, McKeesport, Pa. The gas is admitted through the

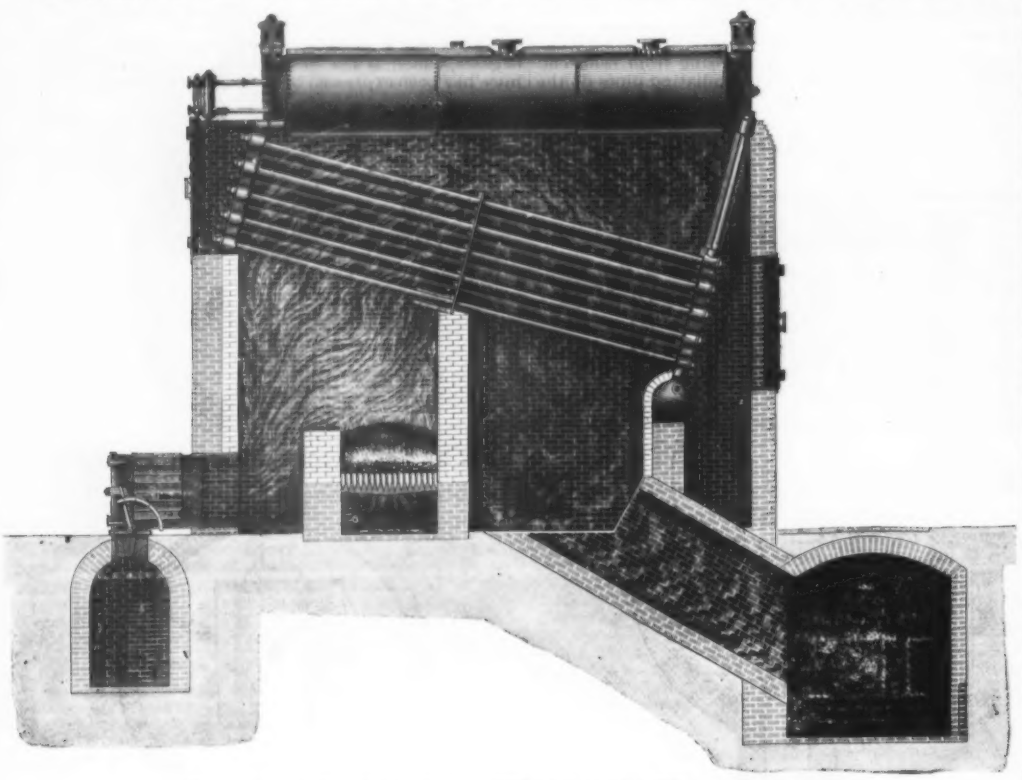


FIG. 10.—WASTE GAS FROM BLAST FURNACES.

bridge wall, the air for the combustion being supplied through alternate openings of a proportionately larger area. The grate bars are kept covered with coal or ashes, and it is evident that, should the gas at any time be shut off, the boiler can be run by burning coal upon the grate bars in the ordinary manner.

Figs. 13 and 14 show a self-acting stoker for bituminous coal, such as is largely used in England and Scotland. In this furnace the grate bars travel continuously in a circuit, carrying the coal from the hopper into the furnace and dumping the ashes at the rear. A short arch at the front of the furnace gives a reverberatory action, which helps to distill the gases from the incoming coal, keep them alight, and prevent smoke.

per pound, or say 50 per cent. more than coal. But owing to the ability to burn it with less losses, it has been found through extended experiments by the pipe lines that under the same boilers, and doing the same work, a pound of petroleum is equal to 1·8 pounds of coal. The experiments on locomotives in Russia have shown the same result. Now, a gallon of petroleum weighs 6·7 pounds (though the standard buying and selling weight is 6·5 pounds), and we may therefore conclude that an actual gallon of petroleum is equivalent under a boiler to twelve pounds of coal, and 190 standard gallons are equal to a gross ton of coal. It is very easy with these data to determine the relative cost. At the wells, if the oil is worth say two cents a gallon, the cost is equivalent to $3.80 per ton for coal at the same place, while at say five cents per gallon, the lowest price at which it can be delivered in New York, it would cost the same as coal at $9.50 per ton. As this is fully twice the cost of coal at that point, there is no hope of economy in substituting petroleum therefor.

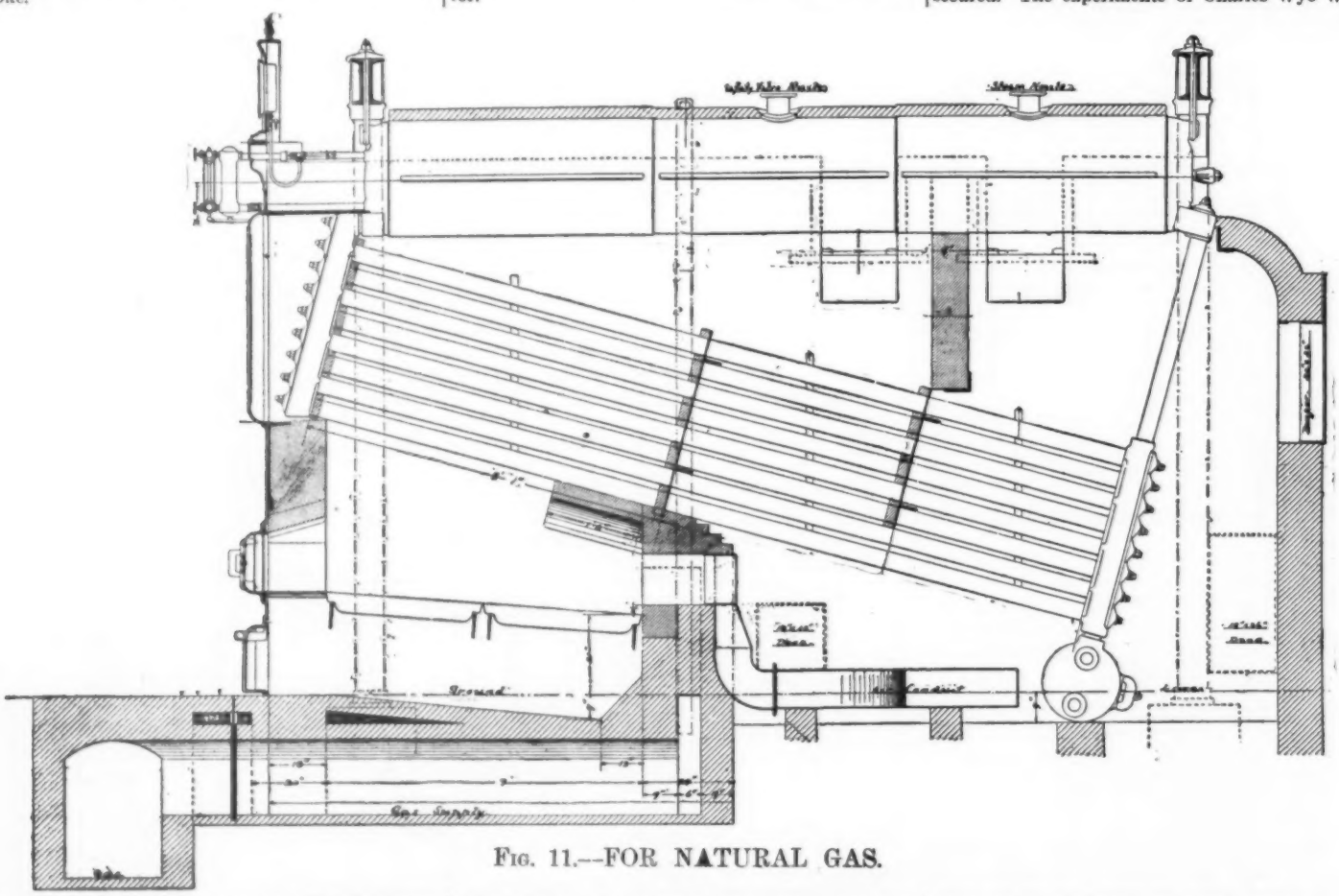


FIG. 11.—FOR NATURAL GAS.

We hear much nowadays about the wonderful saving which is to be expected from the use of petroleum for fuel. This is all a myth, and a moment's attention to facts is sufficient to convince any one that no such possibility exists. Petroleum has a heating capacity, when fully burned, equal to from 21,000 to 22,000 B. T. U.

The relative value of different fuels is largely a question of locality and transportation. For instance, in some parts of Central America they burn rosewood under their boilers, because it is cheaper than coal; while a few years ago in the West it was found, during a coal famine, that Indian corn was the cheapest fuel they could burn. In some places they burn manure only. The Chicago cable railways are run regularly on the offal from the stables of the horse roads, a very small proportion of coal being used to keep it alight.

THE BOILER.

Having now considered the production of the heat with which we are to generate steam, it is necessary next to consider the best means of imparting such heat to the water and retaining the steam made thereby for use. If our purpose was simply to convert water into vapor, an open pan or kettle would answer the purpose very well, as in evaporators for salt and sugar making; but we are making steam under pressure for use in a steam engine or in some other way, and therefore require a closed vessel strong enough to stand the pressure with entire safety. It is not necessary nor is this the time to discuss the relative merits of different forms of boilers. We will confine ourselves to general principles, leaving it for the proper application of these principles to determine the construction of the boiler.

1st. For the purpose of absorbing the heat generated in the furnace, we must have a sufficient extent of what is known as "heating surface" in the boiler. For purposes of economy this should never be less than one, and generally not more than two, square feet, for each 5,000 British thermal units to be absorbed per hour, though this depends somewhat on the character and location of such surface. The range given above is believed to be sufficient to allow for the different conditions in practice, though a far greater range is frequently employed. As, for instance, in torpedo boats, where everything is sacrificed to lightness and power, the heating surface is sometimes made to absorb 12,000 to 15,000 B. T. U. per square foot per hour, while in some mills, where the proprietor and his advisers have gone on the principle that "too much is just enough," a square foot is only required to absorb 1,000 units or less per hour. Neither extreme is good economy.

2d. This surface should be as thin as is consistent with strength. Though you will be told that some experiments have demonstrated that neither thickness nor material make much difference in the amount of heat absorbed, because it is said the ability to receive and give off heat at the surface is less than the power to conduct it, yet in practice it is found desirable to keep the heating surface as thin as possible. In fact, in locomotive fire boxes it has been found impracticable to use iron or steel over $\frac{1}{16}$" thick, as thicker metal will waste away by burning until it arrives at about that thickness. Externally fired boilers, which have been made thicker, have also given trouble from the same cause. You have only to remember that one end of a short rod of iron may burn up in a blacksmith's fire, while the other end is cool enough to handle, to perceive why this may be so. Thin surfaces necessitate small diameters, in order to retain adequate strength.

3d. This surface should be so arranged that the gases from the fire shall strike it at right angles or nearly so, instead of gliding along parallel to the surface. It is a well known fact that heat is not readily transmitted to or from air or gas except by direct contact of the particles. When the heated gases pass in parallel streams along a surface, only the layer next the surface is affected, and one a little way off may be as hot or as cold as it was at the beginning. Hence, it is necessary to break up these currents, and bring every part into contact with the surface, if a maximum effect is to be secured. The experiments of Charles Wye Williams show this conclusively. He found that in a tubular boiler a square foot of tube-sheet surface evaporated several times as much water as a foot of the tube surface, and that the first foot of the tube did as much work as the next twelve. The reason is easily seen. The products of combustion entering the tubes impinge

upon the tube sheet, and the rapid succession of heated particles in contact causes a large amount of heat to be imparted to the surface. In the first foot of the tube the gases are in a commotion, owing to the conflicting currents at the mouth, and so many more particles come into contact with the surface than subsequently, when they have assumed a steady parallel flow along the tube.

4th. The next important condition for making the heating surface efficient is a circulation of the water, sweeping away the particles of steam as fast as formed, and bringing new portions of the water in contact with the heating surface. In an open pan, or a kettle of ordinary proportions, this circulation takes place by a series of currents, upward in places and downward in others, caused by the differing specific gravity of the fluid in consequence of slight differences in temperature. But the more intricate the structure becomes, and the greater the amount of heating surface for a given space, the more these currents interfere with each other, and it becomes necessary to provide some means for directing and separating them. So little is this understood by the boiler makers, and some engineers who design ordinary tubular boilers, that these boilers are frequently crowded with tubes to the very shell, leaving the return currents to struggle back the best they can. In the best forms of water tube boilers, all the water is made to proceed in a circuit through all the generating portions of the boiler, so that no interfering currents can occur to check the flow. So far as I am now aware, the credit of first employing this mode of circulating the water in a practicable boiler is due to an American, F. J. Dimpfel, in 1850. He was followed in 1856 by Stephen Wilcox, and, later, in 1863, it was adopted in England by Mr. Ingliss. I speak of this particularly because it is one of the most important steps toward securing efficiency and safety in steam generators made in this century.

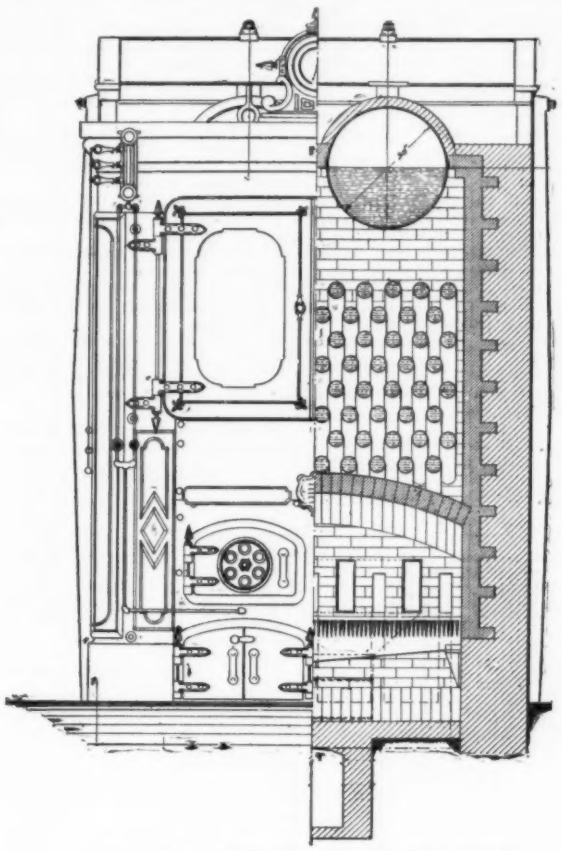


FIG. 12.—FOR NATURAL GAS.

This circulation of all the water in a determined course through all parts of the boiler used for generating purposes does more than the simple function above described. It keeps all parts at one temperature, avoiding the strains of unequal expansion. It lessens the tendency to scale, washing the sediment away from the heating surface in most waters, and prevents in a large measure the "pitting" which sometimes occurs in certain waters.

An experiment made on the steamship Benefactor some years ago demonstrated this in a remarkable manner. With the ordinary marine boiler, which was displaced, it had been the custom to carry a supply of extra tubes, several of which had to be put in every voyage because of pitting from the action of the water from the surface condenser, notwithstanding a quantity of zinc was kept in the boiler to prevent such action. When the water tube boiler having the defined circulation was substituted, it was found that there was no pitting of the tubes, but that the zinc rapidly disappeared. The explanation was that the circulation brought all of the water into contact with the zinc, whereby its corrosive quality was neutralized, while in the former boiler with a haphazard circulation only a portion was neutralized by the zinc and the rest satisfied its appetite on the iron.

5th. Another element we want in our boiler to make it efficient is sufficient water surface for the not too rapid evolution of the steam. This is a point frequently forgotten in designing boilers, particularly sectional boilers. If steam rises from a surface of water faster than about 2 ft. 6 in. to 3 ft. per second, it carries water with it in the form of spray, and when a fine spray is once formed in steam it does not readily settle against a rising current of very low velocity. It is said that a current of 1 ft. in a second will carry with it a globule of water $\frac{1}{1000}$ of an inch in diameter. Do you think that very small? The largest drop of rain does not exceed $\frac{1}{8}$ of an inch in diameter. The viscosity of air and steam is so great that very fine mist will scarcely settle at all, as we have all seen in a foggy morning. A misty rain falls very slowly. So in steam the entrained water falls slowly, and it is necessary that provision shall be made for that if we would have dry steam. In a boiler having such a circulation as above described, the steam is nearly all delivered at one end and is generally mixed with water to a large extent. If, however, the steam is taken off at the other end, and the horizontal flow is sufficiently slow, the water will all settle, and only dry steam will be delivered.

This matter of large water surface is also important, to prevent too rapid fluctuations in water level.

6th. Steam and water capacity. It is remarkable how an old idea will continue to live and perpetuate itself long after it should have been dead. I sometimes think the fable of a cat having nine lives was intended to symbolize the tenacity of a rooted prejudice—such a one, for instance, as the necessity of large steam room in a boiler to allow for fluctuations in the supply and demand for steam. A reasonable steam room is necessary to prevent water being entrained with the steam, but as a reservoir of power it has very little value. When we recollect that 15,000 cubic feet of steam at 75 lb. pressure is required per hour for 100 h. p., and that in order that the pressure may not fall more than 10 lb., nine times that capacity, or 135,000 cubic feet, must be

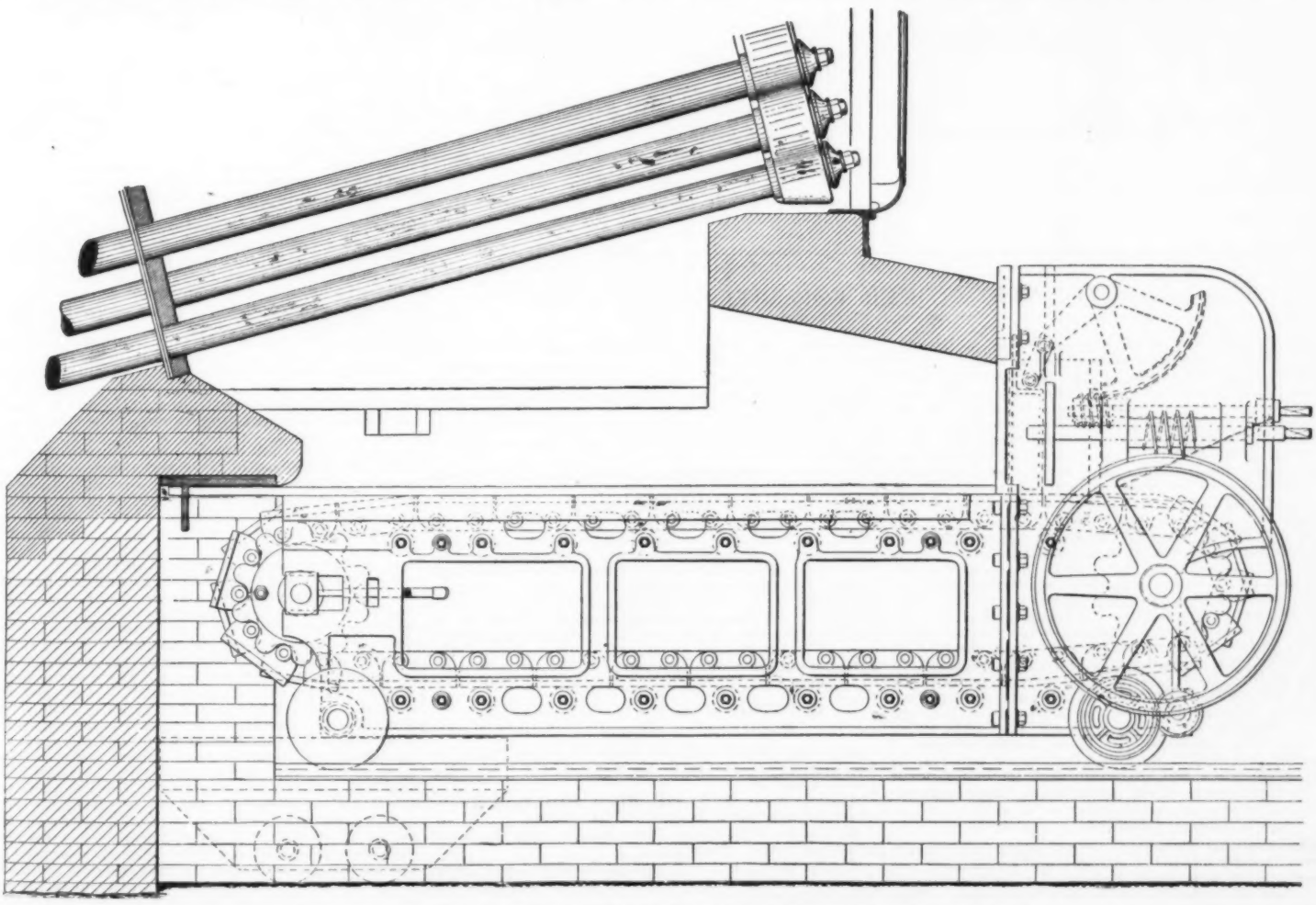


FIG. 13.—AUTOMATIC STOKER FOR BITUMINOUS COAL.

provided, we can realize the utter fallacy of depending upon any available steam room for that purpose. Supposing even we require it only *one minute*, when a fresh fire is put on, we still must have 2,250 cubic feet of steam room, provided that no steam is supplied to it, in order that we may keep our 100 h. p. engine running with a drop of only 10 lb. pressure in a minute. This demands a steam drum *twelve feet in diameter and twenty feet long*. A steam space which the wildest advocates of its necessity consider ample has only enough capacity to supply the engine less than *three seconds*, with a fall of 10 lb. pressure in that time. Any available steam space is therefore of no account as a reservoir of steam to overcome fluctuations. But water space is of more value.

When the pressure of steam in contact with water falls, a portion of that water is converted into steam, proportioned to the decrease of temperature. So when the steam in a boiler falls from 75 lb. to 65 lb., about 1 per cent. of the water will be changed to steam. Three thousand four hundred pounds will therefore give off steam enough for 1 horse power for an hour, or 57 lb. for one minute; or say 1 cubic foot, at that temperature, will supply 1 horse power for one minute, with a loss of 10 lb. pressure. This is less than is usually supplied in a well proportioned boiler, being an average of about 1 in. depth over the whole heating surface.

Too great a water capacity is, however, a disadvantage, as it makes the boiler slow steaming. It is like too much fly wheel on an engine, being a loss rather than a gain. The ability to steam quickly is of much importance in a boiler, as it enables the supply of steam to vary with the demand.

Another important point to consider in designing a boiler is the facility for cleaning the surfaces, both exterior and interior. The surfaces which are exposed

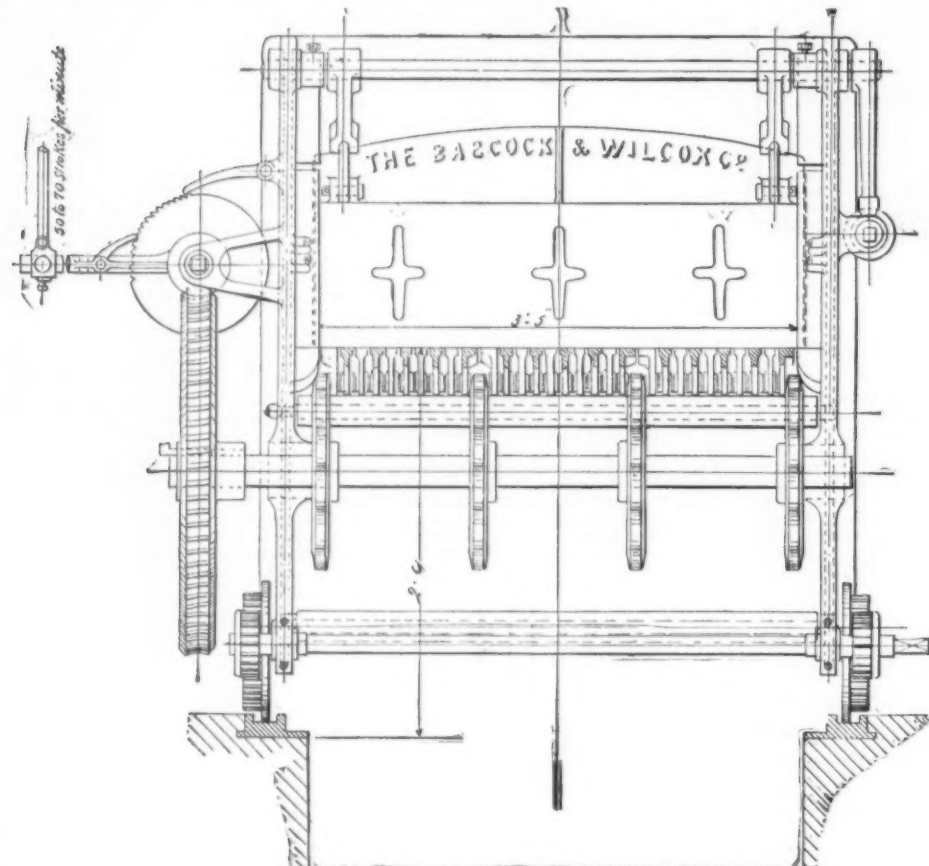


FIG. 14.—AUTOMATIC STOKER FOR BITUMINOUS COAL.

to the products of combustion are liable to become coated with unburned carbon and dust, which, in the course of time, forms a layer, through which the heat cannot readily pass, and, as a consequence, the economy of the boiler is greatly lessened thereby. Finely divided carbon, like lamp black or soot, is a very good non-conductor, and with bituminous coals it is difficult to prevent the formation of such coating upon the heating surfaces. Again, the interior of the boiler is liable to become covered with an incrustation from the impurities in the water, which is also a bad conductor, and, when allowed to collect, will greatly deteriorate the efficiency of the boiler. It has been estimated that a coating of one-sixteenth of an inch of scale will cause a loss of 13 per cent. fuel, and the loss increases in a greater ratio than the increase of thickness. You will be told by parties who manufacture boilers that are inaccessible for cleaning that the circulation of the water will prevent any formation of scale. This is not true, although rapid circulation will retard the formation of scale, and possibly, in some waters, it will, to a large extent, prevent it. Yet in some other waters scale will form in any construction of boiler which can be made. It is therefore highly important that access should be had to every portion of the interior of the boiler, for the purpose of cleaning, not only if we would maintain a boiler at its highest efficiency, but also to prevent its being burnt out in consequence of the presence of thick incrustation.

SAFETY.

We have now considered the principal points necessary to render our boiler efficient and economical, but there is another quality of quite as great importance, if, in fact, it be not of the greatest importance. That is a structure which will not be liable to explode under the pressure of the steam and the contingencies of use. Simple strength is not enough. A while ago, a boiler in England which had been made with extra care, and of much more than ordinary strength, exploded with disastrous effect some time after all fire had been removed from beneath it. The strains due to unequal cooling had been greater than the strength of the material would stand, and as soon as it began to give, the pressure within completed the destruction. The strains due to unequal heating or cooling of different parts are the most prolific source of explosions, and where they do not result in disaster, they weaken the parts of large shell boilers so greatly that they are not considered safe by cautious men after a few years of use. There is no one thing which requires more careful thought in designing boilers, and no one thing is generally more neglected.

It is probably impossible to entirely avoid such differences in expansion. If we have provided a thorough and rapid circulation of water in the boiler, there can be very little differences in temperature while firing up or making steam; but when cooling off, or with the fire door open and a cold stream of air rushing in upon heated surfaces, the circulation ceases, and some parts will cool while others are still hot. Also when a careless fireman blows down his boiler with the brickwork still glowing hot, some parts are overheated, and difference in expansion must take place. It is therefore an important problem to so design a boiler that such unequal expansion shall not exert deteriorating strains, and no serious harm be done thereby. This probably is best done by making the boiler elastic in the line of such strains.

Another direction in which to look in designing a safe boiler is to so construct it that any one part may give out without involving the whole in a destructive explosion. In a water tube boiler, for instance, the parts most exposed to destruction are the tubes, but when one of these gives out it merely opens an aperture equal to a moderate safety valve, and no impetuous rush of water or sudden evolution of steam, on a rapid reduction in pressure, is possible. Again, if the water is divided into a large number of small portions, there can be no united rush of the solid body toward the opening, when a larger part gives out.

Thus we have considered briefly some of the problems necessary to solve, and the conditions which must be secured in designing a steam generator which shall combine the elements of economy, efficiency, safety, and durability. The perfect boiler is yet to be made, and quite possibly some one of the young gentlemen who have so patiently listened to me to-day is to be that benefactor of the human race who will supply the world with a boiler which shall be not only absolutely safe at the high pressures which are sure to be employed in the future, but shall secure the last per cent. of economy, and be entirely independent of the personal equation of its fireman.

ELECTRIC RAILWAYS IN AMERICA.

NOW IN OPERATION.

Appleton, Wis.—Appleton Electric Street Railway; overhead conductor, 4½ miles, 5 motor cars. Van Depoele system.

Asbury Park, N. J.—Sea Shore Electric Railway; overhead conductors, 4 miles. Daft system.

Baltimore, Md.—Union Passenger Railway Co.; overhead conductor. Daft system.

Binghamton, N. Y.—Washington Street and State Asylum Electric R.R.; overhead conductor, 5½ miles. Van Depoele system.

Denver, Col.—Denver Tramway Co.; conduit, 4 miles. Short-Nesmith series system.

Detroit, Mich.—Detroit Electric Railway Co.; overhead conductor, 2 miles, 4 motor cars. Van Depoele system. Highland Park Railway Co.; overhead conductors, 3 miles, 2 motor cars.

Gratiot, Mich.—Gratiot Electric Railway Co.; overhead conductor, 1 motor car. Van Depoele system.

Kansas City, Mo.—Kansas City Electric Railway Co Henry system.

Lima, O.—Lima Street Railway Motor and Power Co.; overhead conductor, 6½ miles, 7 motor cars. Van Depoele system.

Los Angeles, Cal.—Los Angeles Electric Railway Co; overhead conductor, 5 miles, 4 motor cars. Daft system.

Mansfield, O.—Overhead conductors. Daft system.

Montgomery, Ala.—Capital City Electric Street Railway Co.; overhead conductor, 11 miles, 20 motor cars. Van Depoele system.

Port Huron, Mich.—Port Huron Electric Railway Co.; overhead conductors, 2¾ miles, 3 motor cars. Van Depoele system.

St. Catharines, Ont.—Overhead conductor, 6 miles. Van Depoele system.

Scranton, Pa.—Scranton Suburban Railway Co.; overhead conductor, 2½ miles, 3 motor cars. Van Depoele system.

Wichita, Kan.—Wichita, Riverside and Suburban R.R. Co.; overhead conductor, 4 miles, 6 motor cars.

Windsor, Can.—Windsor & Walkerville Electric Railway Co.; overhead conductor, 1½ miles, 1 motor car. Van Depoele system.

Woonsocket, R. I.—Woonsocket Street Railway Co.; overhead conductors.

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Ansonia, Conn.
Allegheny, Pa.
Dayton, O.
Elsinore, Cal.
Harrisburg, Pa.
Ithaca, N. Y.
Jamaica, N. Y.
Lakeside, O.
Los Angeles, Cal.
Middletown, Conn.
New York, N. Y.
Pittsburg, Pa.
Richmond, Va.
San Diego, Cal.
St. Joseph, Mo.
Worcester, Mass.
Wilmington, Del.

NEW ROADS PROJECTED.

Alameda, Cal.
Atlanta, Ga.
Bangor, Me.
Bellevue, Pa.
Biddeford, Me.
Birmingham, Ala.
Boston, Mass.
Bridgeton, N. J.
Bayonne, N. J.
Brookline, Mass.
Brooklyn, N. Y.
Butte, Mont.
Carbondale, Pa.
Chicopee, Mass.
Cincinnati, O.
Coney Island, N. Y.
Elizabeth, N. J.
Eureka, Cal.
East Cambridge, Mass.
Easton, Pa.
Framingham, Mass.
Galveston, Tex.
Flushing, N. Y.
Fort Smith, Ark.
Jersey City, N. J.
Jacksonville, Fla.
Lincoln, Neb.
Milwaukee, Wis.
Muncie, Ind.
Newark, N. J.
Newton, Mass.
Newton, Kan.
Oakland, Cal.
Ontario, Cal.
Orange, N. J.
Oswego, N. Y.
Passadena, Cal.
Philadelphia, Pa.
Plainfield, N. J.
Pensacola, Fla.
Port Chester, N. Y.
Rochester, N. Y.
Rockaway, N. Y.
Scranton, Pa.
San Francisco, Cal.
San Jose, Cal.
San Antonio, Tex.
Springfield, Mass.
St. Augustine, Fla.
St. Paul, Minn.
Tacoma, Wash. Ter.
Tiffin, O.
Winston, N. C.
Westfield, Mass.
Wooster, O.

Columbus, O.—The electric railway is constructed upon the system of Prof. John H. Short, of Denver, Col., formerly of Columbus. It is called the series system, because the same current is sent through each car in succession, as is done in the arc system of electric lights. This road will be the second ever put in under this system. Two trains of cars will be run. The cars will have a carrying capacity of 120 passengers each. The speed will be about 10 miles an hour.

Dayton (Ohio) White Line Street Railway Co.—Work was begun on this new road Aug. 1, and it is expected that the road will be opened by Nov. 1. They will use the Van Depoele system, having part overhead wires and part underground conduit. The total length of track will be 8½ miles of 4 ft. 8 in. gauge, 38 lb. rail, 16 cars, 13 motors. The capital stock of the company is $200,000, and the officers are: President, John A. McMahon; secretary, Charles D. Iddings; treasurer, Michael A. Nipgen.

Binghamton, N. Y.—The electric railway on Washington Street, running to the State asylum, has now been in operation about four months and has proved entirely satisfactory to the owners. The six motor cars run on an average over 60 miles a day each. One hundred and seventy-five thousand passengers have been carried since the use of the electric motors was begun, more than twice as many as were carried by horses during a similar period. The electric outfit is from the Van Depoele company, and the managers of the road speak in high terms of their satisfaction with its performance. The road has grades as high as seven per cent. which are got over without difficulty.

St. Catharines, Can.—The St. Catharines, Merritton and Thorold Street Railway Co. ran its first electric car over its road Oct. 5, and since that date it has run on schedule time with the horse cars without interruption. The line, of nearly six miles, follows the Welland canal closely, and is full of curves and grades. There are 23 grades, the steepest being 6·33 per cent., the lowest 0·87 per cent., averaging about 4 per cent. The road is extremely tortuous, having no less than thirty-three curves. Mr. E. A. Smyth, the president of the road, expresses his unqualified satisfaction with the performance of electricity as a motive power for street cars on his road, and expects soon to have twelve cars fully equipped and running. This road employs the Van Depoele motors and an overhead conductor, and its installation adds one more to the rapidly growing list of street railways successfully equipped by the Van Depoele company. The railway company have built a new power station for themselves, leasing water power from the Canadian government on the Welland canal, paying them at the rate of about one dollar per horse power per annum. They have over 400 actual horse power at their water wheel. Having such an

abundance of power, the company have arranged to run several motors along the line for various manufacturers, so that by January 1 next it is expected that the cost of running the cars with electric power will be reduced to about thirty cents per day per car. A 100 horse power generator is now in operation, and another is intended to be placed shortly. The motor used on the car is of 15 horse power.

The West End Street Railway Co., Boston, Mass.—The trials of the experimental electric car, recently received from New York, have proved very satisfactory. Further tests are going forward in order to determine the most economical arrangement of the motor for the particular work required. The car will probably be put in regular passenger service on the Cambridge line early in November.—*Electrician.*

ON STORAGE BATTERIES FOR ELECTRIC LOCOMOTION.*

By Prof. ANTHONY RECKENZAUN, of Philadelphia.

THE idea of employing secondary batteries for propelling vehicles is almost contemporaneous with the discovery of this method of storing energy. To Mr. Plante more than to any other investigator much of our knowledge in this branch of electrical science is due. He was the first to take advantage of the action of secondary currents in voltaic batteries. Plante is a scientist of the first grade, and he is a wonderfully exact experimenter. He examined the whole question of polarization of electrodes, using all kinds of metal as electrodes and many different liquids as electrolytes, and during his endless researches he found that the greatest useful effect was produced when dilute sulphuric acid was electrolyzed between electrodes of metallic lead.

A set of Plante original cells was exhibited for the first time in March, 1860, before the Paris Academy of Sciences. Scientists admired and praised it, but the general public knew nothing of this great discovery, thus brought to notice. Indeed, at that period little commercial value could be attached to such apparatus, since the accumulator had to be charged by means of primary batteries, and it was then well known that electrical energy when produced by chemical means in voltaic cells, was far too expensive for any purpose outside the physical laboratory or the telegraph office.

It was twenty years after this exhibition at the Academy of Sciences in Paris that public attention was drawn to the importance of storage batteries, and that Mr. Faure conceived the idea of constructing plates consisting of lead and oxides of lead. At that time the advantages accruing through a system of electrical storage could be fully appreciated, since electrical energy was already being produced by mechanical means through the medium of dynamo-electric machines.

It was the dynamo machine which created the demand for the storage battery, and the latter was introduced anew to the public at large and to the capitalist with great pomp and enthusiasm. One of Faure's accumulators was sent to Sir William Thomson, and this eminent scientist in the course of experiments ascertained that a single cell, weighing 165 lb., can store two million foot pounds of energy, or one horse power for one hour, and that the loss of energy in charging did not exceed 15 per cent. These results appeared highly encouraging. There we had a method of storing that could give out the greater part of the energy put in. The immense development which the electric transmission of energy was, even at that early day, expected to undergo pointed to the fact that a convenient method of receiving large quantities of transmitted energy, and of holding it in readiness until wanted, must be of the highest importance. Numerous applications of the Faure battery were at once suggested, and the public jumped to the conclusion that a thing for which so many uses could be instantly found must necessarily be a profitable investment, and plenty of money was provided forthwith, not with the idea of commencing careful experiments, and developing the then crude invention, which would have been the correct thing, but for manufacturing tons of accumulators in their first and immature form.

I need not describe the disappointments which followed the first unfulfilled hopes, nor repeat the criticism that was heaped upon the heads of the early promoters. Those early hopes were untimely and unreasonable. A thousand difficulties had to be overcome, scientific difficulties and manufacturing difficulties. This invention, like most others, had to go through steady historical developments and evolution, and follow the recognized laws of nature, which are against abnormal and instantaneous maturity. The period of maturity has also been retarded by injudicious treatment, but the ultimate success was inevitable. Great advances have been made within the last few years, and I propose now to offer a few facts and figures relating to the present state of the subject with reference to the application of storage batteries to locomotive purposes. It is not within the province of this paper to discuss all the different inventions of secondary batteries nor to offer any suggestions with regard to priority. Therefore I will confine myself to general statements.

I am aware of the good work that was done in the United States by Kirchhoff, twenty-six years ago, and of the more recent work of Mr. Brush, of Cleveland, Mr. Julien and others, but I am more particularly acquainted with the recent achievements of the New York Accumulator Co., who own the rights of the Electrical Power Storage Co., of London. I have used the batteries of the latter company for propelling electric boats and electric steam cars. The first of the boats was the Electricity, which was launched in September, 1882, and which attained a speed of seven miles an hour for six consecutive hours. Since then a dozen electric boats of various sizes have been fitted up and worked successfully by means of storage batteries and motors of my design.

The most important of these were the launch Volta, and another similar craft, which is used by the Italian government for torpedo work in the harbor of Spezia. In the measured mile trial trips the Italian launch gave an average speed of 8·43 miles an hour with and against the tide. The hull of this vessel was built by Messrs. Yarrow & Co., and the motors were manufactured by Messrs. Stephens, Smith & Co., of London. The Volta, which was entirely fitted by the latter firm, is 37 feet long and 7 feet beam, she draws 2' 6" of water when carrying 40 persons, for whom there is ample sitting accommodation. There are 64 cells in this boat. These are placed as ballast under the floor, and actuate a pair of motors and a screw, coupled direct to the armature shaft, running at 700 revolutions a minute. We crossed the English Channel with this boat in September last year, leaving Dover at 2:40 in the morning, arrived at Calais at 2:30 P. M., stayed about an hour in the French harbor for luncheon, and floated into Dover docks the same evening at 6:30 with full speed. The actual distance traversed without entirely discharging the cells was 54 miles. The current remained constant at 28 amperes until 5 P. M., and it only dropped to 25 amperes at the completion of the double voyage between England and France. Several electric launches are now being constructed in London, and one in New York, by the Electric Accumulator Company.

M. Trouve exhibited a small boat and a tricycle, both worked by Plante accumulators, at Paris, in 1881.

The first locomotive actuated by storage batteries was used at a bleaching works in France, in 1882. During the same year I designed an electric street car for the storage company, and this was tried on the lines of the West Metropolitan Tramways in March, 1883. It had accommodation for forty-six passengers. This car had many defects, and I reconstructed it entirely, and ran it afterward in its improved form on the South London Tramways, and also on a private track at Millwall, where it is now in good condition, and have a similar car in Berlin. M. Phillippart exhibited a car in Paris, and M. Julien made successful experiments in Brussels, Antwerp, and Hamburg. Mr. Elieson is running storage battery locomotives in London. Mr. Julien has also been experimenting with a car in New York, and I believe one is in course of construction for a line in the city of Boston. Messrs. W. Wharton, Jr. & Co. have a storage battery car running at Philadelphia on Spruce and Pine Streets, and this energetic firm is now fitting up another car with two trucks, each carrying an independent motor, similar to my European cars.

I have mentioned all these facts in order to show that there is a considerable amount of activity displayed in the matter of storage batteries for street cars, and that continued and substantial progress is being made in each successive case. The prejudices against the application of secondary batteries are being rapidly dispelled, and there are indications everywhere that this method of propulsion will soon take a recognized place among the great transit facilities in the United States. I feel convinced that this country will also in this respect be far ahead of Europe before another year has passed over our heads.

There are several popular and, I may say, serious objections to the employment of storage batteries for propelling street cars. These objections I will now enumerate and endeavor to show how far they are true, and in what measure they interfere with the economical side of the question.

First objection: The loss of energy, which amounts in practice to 20, and sometimes 30 per cent. Now, every method of storing or transmitting energy involves some waste, but in saying this we need not condemn the system, for after all the term efficiency is only a relative one. For instance, a 10 horse power steam engine consumes three times as much fuel per horse power hour as a 1,000 horse power engine does, yet this small engine must be, and is regarded as, one of the most economical labor saving appliances known to us. Considered as a heat engine, the efficiency of the most economical steam motor is but 10 per cent.—90 per cent. of the available units of heat contained in coal being lost during its transformation into mechanical energy. Thus if we find that the storage battery does not return more than 70 per cent. of the work expended in charging it, we ought not condemn it on that account until we have ascertained whether this low efficiency renders the system unfit for any or all commercial purposes. It is needless to go into figures in order to show that, when compared with animal power, this objection drops into insignificance.

The second, more formidable, objection relates to the weight of storage batteries, and this involves two disadvantages, viz., waste of power in propelling the accumulator along with the car, and increased pressure upon the street rails, which are only fitted to carry a maximum of 5 tons distributed over 4 points, so that each wheel of an ordinary car produces a pressure 1¼ tons upon a point of the rail immediately under it.

The last mentioned objection is easily overcome by distributing the weight of the car with its electrical apparatus over 8 wheels or 2 small trucks, whereby the pressure per unit of section on the rails is reduced to a minimum. With regard to the weight of the storage batteries, relatively to the amount of energy the same are capable of holding and transmitting, I beg to offer a few practical figures. Theoretically, the energy manifested in the separation of one pound of lead from its oxide is equivalent to 360,000 foot pounds, but these chemical equivalents, though interesting in themselves, give us no tangible idea of the actual capacity of a battery.

Repeated experiments have shown me that the capacity of a secondary battery cell varies with the rate at which it is charged and discharged. For instance, a cell such as we use on street cars gave a useful capacity of 137·3 ampere hours when discharged at the average rate of 45·76 amperes, and this same cell yielded 156·38 ampere hours when worked at the rate of 22·34 amperes. At the commencement of the discharge the e. m. f. of the battery was 2·1 volts, and this was allowed to drop to 1·87 volts when the experiment was concluded. The entire active material contained in the plates of one cell weighed 11·5 lb., therefore the energy given off per pound of active substance at the above high rate of discharge was 62,225 foot pounds, and when discharging at the lower rate of 22·34 amperes the available useful energy was 72,313 foot pounds, or nearly 2·2 electrical horse power per pound of active matter. But this active substance has to be supported, and the strength or weight of the support has to be made sufficiently great to give the plate a definite strength and durability. The support of the plates, inclusive of the terminals above referred to, weighs more than the active material, which consists of peroxide of lead and spongy lead, so that the plates of one cell weigh actually 26·5 lb. Add to this the weight of the receptacle and acid, and you get a total of about 41 lb. per cell when in working order. Seventy of these cells will propel an ordinary street car for four hours and a half while consuming the stored energy at the rate of 30 amperes, or over 5·6 electrical horse power. The whole set of 70 cells weighs 2,870 lb., which is barely one-fifth of the entire weight of the car when it carries 40 adult passengers. Therefore the energy wasted in propelling the accumulator along with a car does not amount to more than 20 per cent. of the total power, and this we can easily afford to lose so long as animal power is our only competition. From numerous and exhaustive tests with accumulator cars in this country and abroad, I have come to the conclusion that the motive power for hauling a full-sized street car for 15 hours a day does not exceed $1.75, and this includes fuel, water, oil, attendance, and repairs to engine, boiler, and dynamo. We have thus an immense margin left between the cost of electric traction and horse traction, and the last objection, that relating to the depreciation of the battery plates, can be most liberally met, and yet leave ample profits over the old method of propulsion by means of animals.

The advantages of storage battery street cars for city traffic are self-evident, so that I need not trouble you with further details in this respect, but I would beg those who take an interest in the progress of electric locomotion to give this subject all the consideration it deserves, and I would assure them that the system which I have advocated in this brief but very incomplete sketch is worthy of an extended trial, and ready for the purposes set forth. There is no reason why those connected with electric lighting interests in the various cities and towns should not give the matter their special attention, as they are the best informed on electrical engineering, and already have a local control of the supply of current needed for charging.

The subject was then discussed. Dr. Moses suggested that Prof. Reckenzaun, not being familiar with our English idiom, was likely to be misunderstood in his statement that "M. Plante turned to profit" certain inventions, when he meant that M. Plante had availed himself of those inventions. Dr. Moses stated that M. Plante has never turned to pecuniary profit any one of those brilliant inventions connected with the secondary battery which have immortalized his name. Continuing, the speaker said:

"I would like to ask him with regard to the running of street cars. That seems to me a most important application of the secondary battery. Will he give us the weight of the car he speaks of as being in use in Philadelphia, and which he wants us to go and ride upon? I am anxious to know exactly what strength the car has, so that we may not break it down."

I have given the weight of the batteries in the car that we use in Philadelphia. There are eighty cells. Each cell weighs forty pounds. The average horse power is six. Sometimes we only use two, and sometimes when going up grades of five per cent. we use as much as twelve horse power. We never carry more than fifty passengers, because it is impossible to put more than fifty into it. There are seats for twenty-four, and the rest have to stand on the platform steps and in the passageway.

The change of batteries should take three minutes when properly managed. One set of cells is drawn out, and a freshly charged set put in. It takes exactly the same time to charge the cells that it does to discharge them in working the car. One reserved set is sufficient to keep the car continually moving.

The car is pushed into the depot, where the cells are being charged. Therefore, there is no moving of the cells required except taking them out of the car and pushing the fresh one in. One man can attend to that.

The loss of energy from allowing batteries to remain unused is practically nothing. Probably, if the battery were to stand charged three months in a dry place, provided the exterior box is dry, the loss might be ten per cent. I have purposely had a set of cells stand two years charged and never used. I found after two years that there was still a small amount of energy left. As regards the loss of energy by standing idle, it is practically nothing, because no one would think of charging a battery and letting it stand idle three months or a year.

I have made experiments in London with a loaded car pulled by two horses. I put a dynamo between the attachment of the horse and the car, so as to ascertain exactly the pulling, measured in pounds multiplied by the distance traversed in a minute. You will be surprised to know that two horses, when doing their easiest work, drawing a loaded car on a perfectly level road, exert from two to three horse power. I have mentioned a car in Philadelphia where we use between two and twelve horse power. Each horse is capable of exerting eight horse power for a few minutes, and when a car is being driven up a grade, the same as I see in Boston, for instance, pulling a load of passengers up these grades, those two horses are exerting from twelve to sixteen horse power—mechanical horse power. That is the reason that street car horses cannot be run more than three or four hours out of the twenty-four. They would be dead in a few weeks.

The life of the cells, if expressed in pounds, the estimate amounts to nothing at all. The life of the cells must be expressed upon the principle of ampere hours or the amount of energy given off through them. Street car work requires that the cells work their hardest from fifteen to sixteen hours a day. The life of the cells is to be divided first into the life of the box which contains the plates. This box, if appropriately constructed, of correct materials, will last many years, because there is no actual wear. The life of the negative plates will be very considerable, because no chemical action is going on in the negative plate. The negative plate consists almost entirely of sponge lead. The depreciation of the battery is entirely due to the oxidation of the positive plates. If we should make a battery of plates ¼ of an inch thick, it would last many years, but for street car work that would be far too heavy. Therefore, we make the positive plates a little more than one-eighth of an inch thick. I find that the plates get sufficiently brittle to almost fall to pieces after the car has run daily fifteen hours a day for six months. The plates then have to be renewed. But this renewal does not mean throwing away entirely all the plates. The weight is the same as before, because no consumption of material takes place. We take out peroxide of lead instead of red lead. That peroxide, if converted into metallic lead, produces seventy per cent. of metallic lead, so that there is a

* A paper read before the National Electric Light Association, Boston, August, 1887.

loss of thirty per cent. in value. Then comes the question of the manufacture of these positive plates, which, I believe, at the present day are rather expensive, about eight cents a plate for the labor only. But I believe the time will come when battery plates will be manufactured like shoe nails, and the process of renewing the positive plates will be a very cheap one.

The motive power costs two cents per car mile, that is, the steam power and attendance for charging the batteries. We have to allow twice as much for the depreciation of a battery at the present high rate at which we have to pay for the battery—five dollars a box for each cell. But I believe that as soon as the storage battery industry is sufficiently extended, the total cost for propelling these cars will be not more than four cents a mile, or about one half the cost of the cheapest horse traction.

The wear and tear in the case of the storage system is considerable. There is a waste of energy in the dynamo. Secondly, in the accumulator charged by that dynamo. Thirdly, in the motor which is driven by the accumulator. And, fourthly, in the gearing which reduces the speed of the motor to the speed required by the car axles, because it would be difficult to make a motor run at the rate of eighty revolutions to the minute, which is the number of revolutions on the street car axle when running at the rate of ten miles an hour. Take all these wastes, and you find in practice that you do not get more than forty per cent. of the energy given by the steam engine on the car axles. But this is quite sufficient to make this system much cheaper than horse traction.

I can get out of a storage battery almost any horse power I like for ten or twenty per cent. of the length of the line.

I haven't the least objection to a direct system. But when you come to run twenty, or thirty, or fifty cars on one line, you will require such an e. m. f. that it would be impossible to insulate it. The overhead system is applicable to its own particular purposes to a line running. Where there are only five or ten or even twenty cars running on one line, and that line runs through a suburb or a part of a city where there are many houses, that system is to be preferred. The objection to the overhead system is not the want of beauty, but the want of practicability. You have to put your posts very high indeed so as to let great wagon loads of hay and all sorts of things pass underneath. And then you find that trouble comes in winter. When it is snowing hard, a great many difficulties arise. Yet I would advocate that system anywhere except in city traffic. As regards the loss, suppose that the resistance of the overhead lines is one ohm. To draw one car will take an average of 20 amperes, and the only loss will be 20 multiplied by 20, that is, 400 amperes through line resistance. But if there are ten cars, on that line you get 40,000 watts loss of energy, unless you increase the conductor in proportion to the number of cars. If you do that, when you get 100 or even 50 cars, you get an enormous conductor and have a sort of elevated railroad instead of a telegraph wire, as most people imagine an overhead conductor to be.

In regard to using two motors on a car, there are several advantages which it has. One is, because I used two motors in every car in Europe, and always have from the beginning. One of them is, that in case of an accident to one motor the other will bring the car home; secondly, with two motors, we can vary the speed without changing the e. m. f. and the battery. If I want very much power, I put two motors in parallel, getting four times the power that I do with one machine, and an intermediate power of two motors. There is another advantage of having two motors, and that is that we have two driving axles instead of one, and we can go up grades with almost double the facility that way, because the adhesion would be double. These are the main advantages arising from the use of two or more motors. You might introduce more eventually, perhaps. In regard to the mechanical transmission between the motor and the car axle, I have used almost everything that was known at the time, but in order to give you a full and detailed account of the various modes of transmission which I have used, I should have to give you figures to bear out certain experiments, which I should be able to do only in a lecture which would take at least five hours. So I hope that you will kindly excuse me on that point.

With regard to the durability of plates, I have taken into consideration 15 hours a day. In regard to the application of electrical brakes, I will say that that was one of the first ideas that entered my head when I began to use electric motors, and people had that idea long before me. It was not original with me at all. I have used an electric brake, using the motor itself as a brake—that is, as the car runs down a grade, by momentum it generates a current; but this current cannot be used for recharging a battery. It is utter nonsense to talk about that, unless we have a steady grade four or five miles long. The advantages are very small indeed, and the applications which would be introduced by means of automatic cut-outs and governors, and so on, would counterbalance anything that might be gained. As regards going up an incline, of course stopping and starting again has to be done often, and anybody who at any future time makes cars to work by electricity, whether they have storage batteries or not, has to make sufficient motive power to overcome all the difficulties that any line might present. One of the great mistakes which some of the pioneers in this direction made was that they did not put sufficient power upon the cars. You always ought to put on the cars power capable of exerting perhaps 20 or 30 or 40 or 50 per cent. more than is ever demanded in the ordinary street service, so that in case of being snowed up, or any other accident which is liable to occur, you would have plenty of power to get out of the scrape.

A NEW electrical street car is being tried at Philadelphia, Pa. The source of power is electricity stored in accumulators or secondary batteries, and utilized by electric motors which are geared to the axles. The car is much larger than the ordinary street car, and it is believed to be the longest street railway car in the world. It measures over all thirty feet, and its inside measurement is twenty-two feet. It is mounted on two trucks, each having four wheels, and each truck bears an independent electric motor.

HOW TO MAKE A CAMERA BELLOWS.

IN manufacturing photographic apparatus on a large scale, as is now necessary to meet the rapidly increasing demands of the amateur and professional photographer, very little care is taken by some manufacturers to critically test the light-tight qualities of each camera and bellows. Hence it happens that the purchaser sometimes finds, after careful trial, that he has obtained a faulty instrument, which, in these days of quick plates, is especially aggravating. A tight bellows is the most important feature about a modern camera, and it will be the purpose of this article to describe how one can be easily made. Leather, in some countries, is preferred to any other material, but the inferior qualities frequently used for the purpose are affected by moisture and become brittle, and will break at the corners in a short time. Rubber-coated cloth is largely used, on account of its imperviousness to moisture, but has the disadvantage of softening and sticking in a prolonged heat, particularly when the air is very humid, as it sometimes is in the United States, which results in the formation of minute interstices in the cloth support, through which the light will leak. Besides this, it is heavy and will break at the corners.

Mr. Edward Bierstadt, of this city, formerly an amateur photographer, noticing the several weak points in camera bellows, concluded to try paper as a substitute for the above named materials, which proved to be so satisfactory after ten years' use that he has now adopted it exclusively. For large sized bellows a heavy grade of the best calendered Manila paper is advised, since it is tough and pliable, but for small cameras a Japanese paper, commonly called "Japanese leatherette," should be used, as it is remarkably tough, and is a perfect imitation of leather.

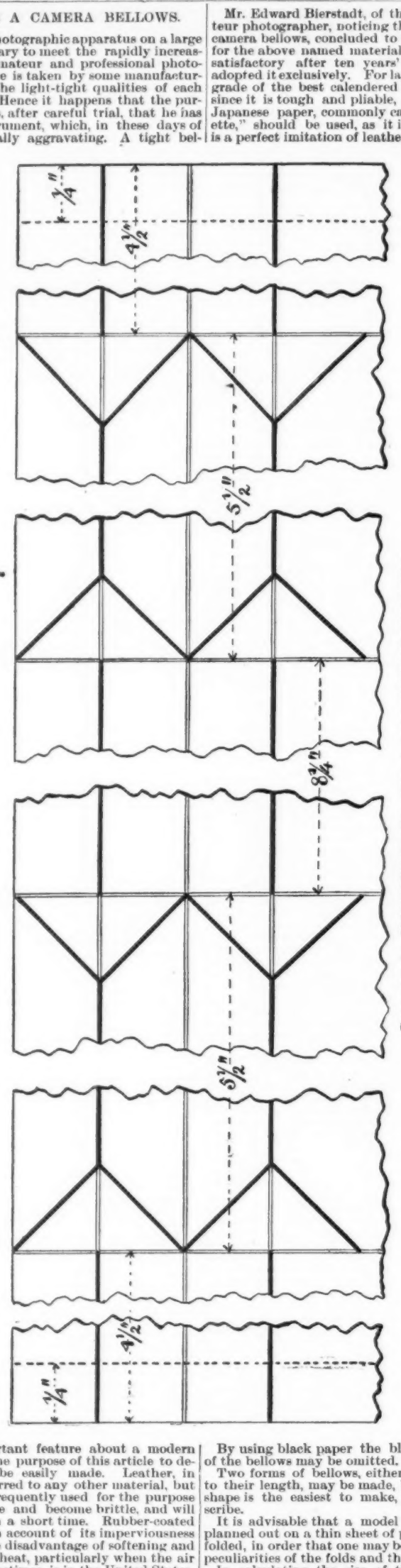


DIAGRAM A.—MEASUREMENTS FOR A 5 × 8 SQUARE BELLOWS.

By using black paper the blackening of the inside of the bellows may be omitted.

Two forms of bellows, either straight or conical, as to their length, may be made, but that of the straight shape is the easiest to make, which we will first describe.

It is advisable that a model of the bellows be first planned out on a thin sheet of paper, then creased and folded, in order that one may become familiar with the peculiarities of the folds and the way of folding.

In calculating the size of the sheet required for a given length of bellows, allowance must be made for the extra length taken up by the folds. If a bellows is to be constructed for a camera adapted for 5 × 5

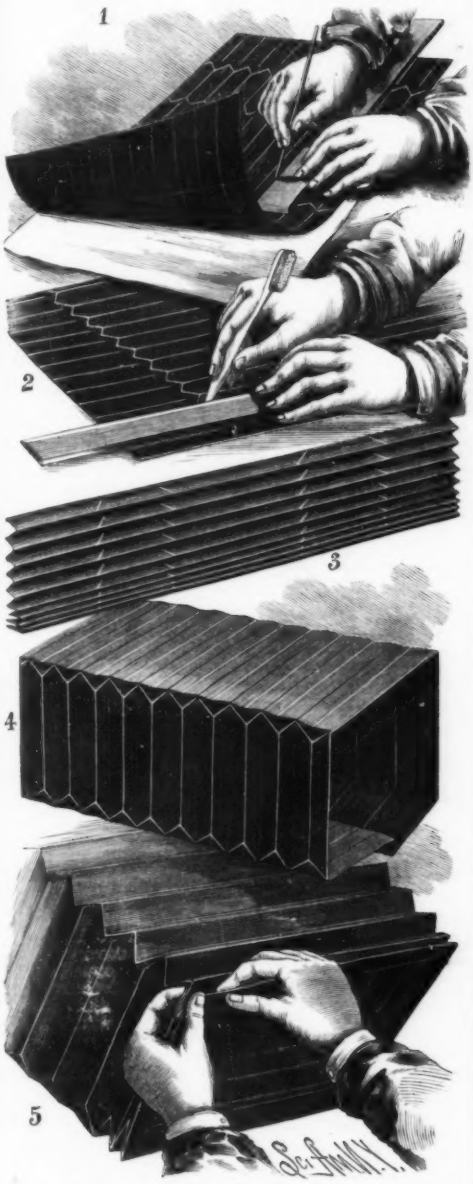
pictures, and it is desired that it have a stretch of fifteen inches, a sheet of paper 29 inches long by 15 inches wide should be selected. For this purpose we recommend a black leatherette paper, to be had from manufacturers of book binders' materials.

A yellow pencil should be used, so that its mark may be easily traced on the black paper, and a sheet of transfer paper, with one side rubbed over with chalk, as large as the bellows sheet, should also be provided.

The principal points to be observed in planning the bellows is to calculate where the outside and the inside folds will come and what portions of such folds are to be creased from the inside and outside.

To ascertain these several positions on a flat piece of paper and properly locate them, so that the folds will all come together in unison when the bellows is formed, is the problem one has to first study.

Diagram A illustrates the actual size of the folds and the method of outlining the sheet with measurements for a 5 × 8 bellows. The sheet, being bent around in the direction of its length to form the bellows, requires that the lines representing the four angles of the bellows be drawn at right angles to the line of the folds, or parallel with the shortest length of the sheet. Two parallel lines are first drawn, 8½ inches apart, equally distant from the center of the sheet, at right angles to



FIGS. 1 TO 5.—CREASING AND FOLDING THE BELLOWS.

its longest length. Then 5½ inches equidistant on the outer side of these lines two other parallel lines.

These four lines represent the extreme four corners of the bellows, which, for convenience, we will call corner lines. They are creased from the inside. (See the four parallel open lines at right angles to the black lines.) The bottom side of the bellows is divided, and an allowance is made for the lap. As the width of each side of a fold of the bellows is to be ¾ of an inch, we next proceed to draw parallel lines, ¾ of an inch apart, across the longest length of the sheet, as shown by the heavy lines in the diagram, commencing ¾ of an inch from the edge. These represent where each fold is to be made, which we will term fold lines.

To find where the corner folds are to come, we next draw four lines, parallel with the first four corner lines, two of which are ¾ of an inch distant from the outside of the two center corner lines, and the other two ¾ of an inch distant inside of the two outer corner lines. When so drawn, we have a series of ¾ inch squares made with respect to the corner lines and fold lines, the squares lying toward each other, on each side of the corner lines. Starting from the edge of the sheet, we now intersect each square with a diagonal line, carrying it outward from the two center corner lines and inward from the two outer corner lines. In the second square the reverse direction is taken. Thus we find the proper location of the corner folds by intersecting all the squares.

Having laid out the location of the folds, the next step is to ascertain which lines are to be creased from the outside and which from the inside of the bellows. Those to be creased from the inside are indicated by open or double lines in the diagram, while the heavy lines are to be creased from the outside.

Fig. 1 in the large engraving shows the manner of transferring the lines to be creased on the inside to the under side of the black sheet. The latter is laid upon a

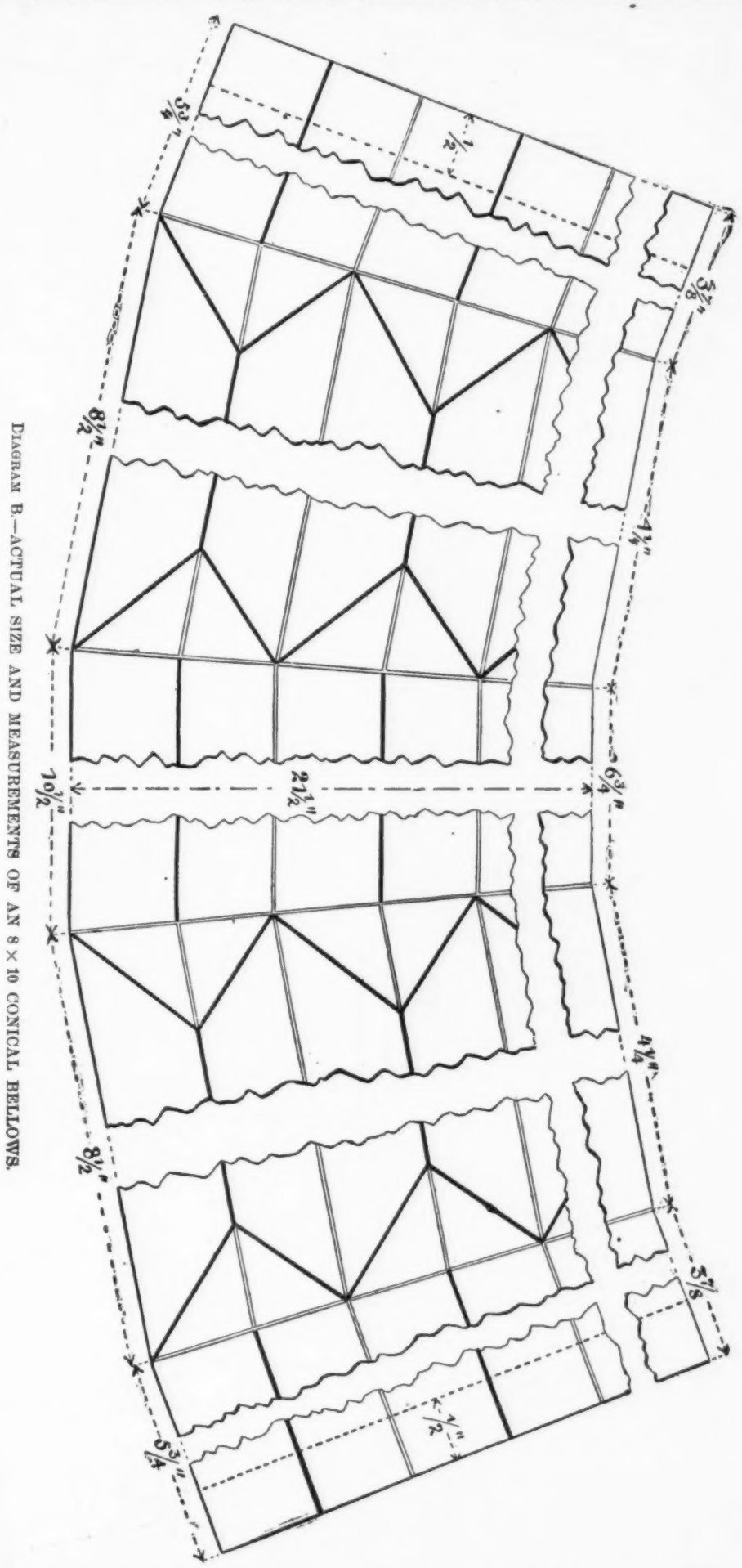


DIAGRAM B—ACTUAL SIZE AND MEASUREMENTS OF AN 8 × 10 CONICAL BELLOWS.

sheet of chalked paper, and with a rule and metal point the double lines drawn on the upper side of the sheet are run over. The pressure of the point is sufficient to leave a distinct white line on the under side of the sheet.

Fig. 2 illustrates the way the lines are creased, which may be done by drawing and pressing the point of a tooth brush handle or a carpenter's square lubricated with paraffine wax over the lines. First the side intended to form the outside of the bellows is creased, then the other side.

The sheet is folded up, after creasing, as shown in Fig. 3, and tightly compressed, which gives the folds a definite, fixed form. The sheet is next drawn out flat and folded transversely to its length at the four corner lines, as shown in Fig. 4, and the lap of a quarter of an inch at the bottom is cemented by glue or mucilage. A simple way to glue the joint is to first secure one end of a long, flat stick in a vise and then slide the bellows over it, allowing the lap to rest on the stick. A slight rubbing pressure on the paper will bring the previously glued surfaces into close contact and make a permanent light-tight joint. When the joint is perfectly dry, then the bellows is formed, as shown in Fig. 5, by commencing at the corners, and gradually crumpling and bending in the creased portions, continuing the manipulation on each corner of each separate fold one at a time. It is surprising to notice how readily the folds harmonize in with each other, provided the sheet has been carefully creased. To render

the bellows waterproof, it is varnished on the outside with two coats of shellac varnish. When secured to the front and rear frames of a camera box, we have a waterproof non-crackable bellows which is absolutely light-tight, tough, and capable of being very compactly folded up. If light-colored paper is employed, the interior of the bellows should be blackened with a varnish composed of shellac and lamp black. If the shellac is dissolved in water, borax or ammonia must be added to make the shellac dissolve.

In making a truncated pyramidical shaped bellows, the plan of laying out the lines for creases and folds is quite similar to that previously described, with the exception that special compensation for the gradual tapering of the bellows has to be calculated for. The width of one-half of the folds is proportionately narrower than the other half.

In Fig. 6 is seen the plan of an 8×10 bellows, in which the solid white lines represent the crease lines for the sunken folds on the outside of the bellows, and the double lines the crease lines for the under or inside folds. The size of sheet required is 24×38 inches.

We first draw a center line in the direction of the length of the bellows, then, supposing the back of the bellows to measure 10⅛ inches, and the front end 6¾ inches in width, we lay off half of this measurement on each side of the center line and connect the ends of the two front and back cross lines. These oblique lines form the two upper radial corner lines of the bellows.

Supposing the sides to measure 8⅛ inches wide on the back and 4¼ inches on the front or small end, we divide the distance at each end and locate the side center lines (see Fig. 6). From these we determine the location, by measurement, of the two lower radial corner lines of the bellows. The bottom of the bellows is then divided, and one-half added to each side of the sides of the bellows, an extra length of ½ an inch being allowed for the lap or joint.

The crease lines for the cross folds are next determined, by first dividing off on the respective center lines in equal distances the width of a double fold, which may be about 1½ inches. The measurement

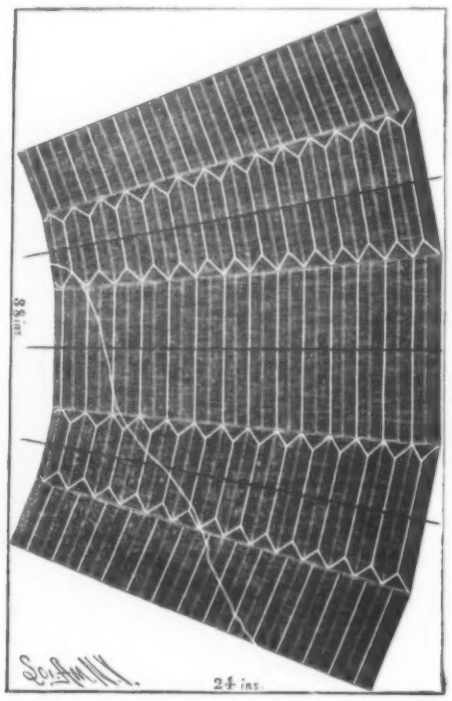


FIG. 6.—PLAN OF AN 8 × 10 TRUNCATED PYRAMIDAL BELLOWS.

should commence from the wide end and proceed toward the small end. Cross fold lines are then drawn between the four radial corner lines in each section, at right angles to their respective center lines, and will meet each other, producing a shape similar to a portion of an octagon. The next step is to locate the position of the intermediate fold. This is done by laying the base of a draughtsman triangle on the base line, or back of line, and drawing a line at 45 degrees inward from the intersection of the corner line with the back line, nearly across the fold, then by reversing the position of the triangle, so that its base is coincident with the next fold line, and drawing another diagonal line at 45 degrees inward from the intersection of the fold line with the radial corner line to where it will cross the other diagonal line. Where they meet will be the proper location of the intermediate fold line. This will be the same for all the intermediate folds. The points for these lines should then be located on the center line, and they should be drawn parallel with the other fold lines between the two center corner lines. Each side of the bellows is measured off in the same way. The corner folds are located precisely as in the case of the rectangular bellows by drawing lines ¾ of an inch distant from the corner lines parallel with the latter, and crossing the squares so formed by diagonal lines, which represent the zigzag lines of the corner folds. Fig. 6 and Diagram B show positions of these lines. The double lines are to be creased from the inside.

One slight objection to this form of bellows is that it is liable to stick and not to freely expand. Hence Mr. Bierstadt has devised a simpler shape, in which the corners of the folds are truncated.

This form is clearly shown in Figs. 7 and 8.

The bellows, by its peculiar construction, may be folded up more compact than any other, and at the same time is so elastic and springy that its folds do not in the least adhere or stick to each other. In Fig. 7 we see the conical shaped sheet after it is creased and cemented, in the process of being changed from the round to the square shape. After the flat sheet is creased, its ends are glued together, which forms a truncated cone. Then it is compressed at the creases into folds, as shown in Fig. 5.

Fig. 8 shows the peculiar corner fold of this bellows, the joint at the bottom, and its compact form when compressed.

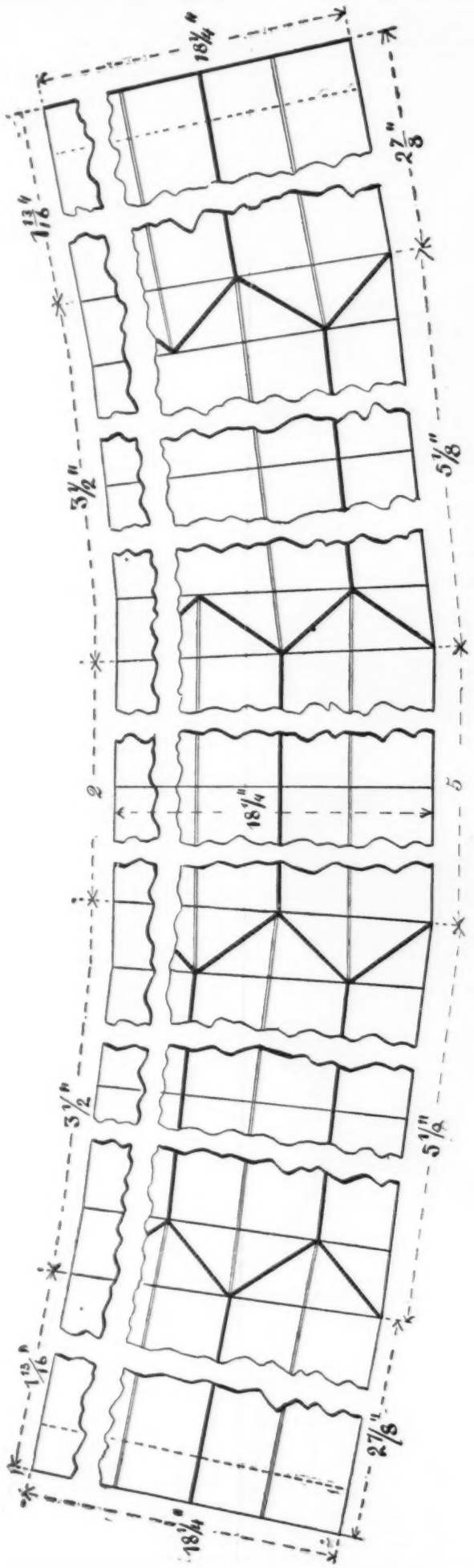


DIAGRAM C.—FULL SIZE AND ACTUAL MEASUREMENTS OF A 4 × 5 TRUNCATED CONICAL PYRAMIDAL BELLOWS.

Diagram C shows the plan and measurements of a bellows adapted for a 4×5 camera, as shown in Figs. 7 and 8.

The special difference in creasing from that shown in Fig. 6 and Diagram B is in the corner folds, which is explained more clearly by referring to Diagram D.

Supposing the inside measure at the back to be 5 in. and at the front 2 in., we locate a center line, C, and lay off the side corner line, D, as heretofore stated. We then divide the center line into spaces equal to the double folds, as in Diagram C, and draw lines parallel to A, extending them on each side as far as side line, D. We next determine the position of the intermediate line, I, by deducting from half the distance between E and A the amount of space between G and H, obtained by dropping a line from the intersection of fold line, E, with corner line, D, to the base line, A, the said line, E F, being parallel with the center line, C. Just here is an important difference. Instead of stopping the intermediate line, I, at the corner line, D, we extend it to

point, J, or a distance beyond the perpendicular line, I F, equivalent to the space between I and F or between E and I. We then draw the line, J, parallel with corner line, D, and have a guide where to draw the zigzag line, since the intermediate lines like I extend to line, J, and the inner fold lines, like A and E, to line, D. By drawing a diagonal line from H to J, across the

FIG. 7.—TRUNCATED CORNERED PYRAMIDAL BELLOWS.

square, K, and from J to E across the square, L, we have the proper location and angle for the corner crease lines. For sides of the bellows we commence from the point, H, and measure off half of the width of the inside of the intended side. Draw a center line perpendicular to its base, and measure off on that the position of the fold lines as described for the top of the bellows. It will be seen that on the sides of the bellows the intermediate lines stop at line, J, while the other fold lines cross the line, J, and meet at E. By

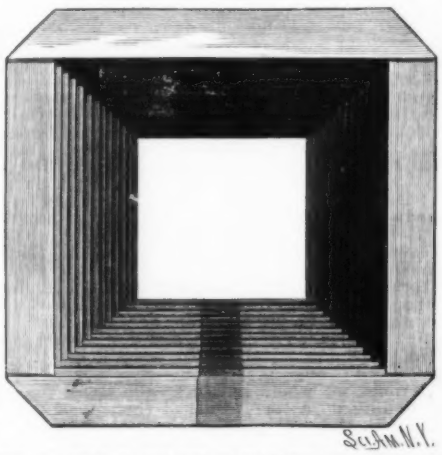


FIG. 8.—BACK OF TRUNCATED CORNERED PYRAMIDAL BELLOWS.

this method a curious skew shape of the cross lines, especially between lines, D and J, is observed, but is necessary in order that the folds may come out in unison.

A bellows constructed after the above plan presents a very neat and light appearance. It requires a little more paper, but is, by reason of its elastic qualities, almost self-acting. It should be remembered that the use of dividers must be avoided, since the slightest puncture in the paper will damage the bellows. If

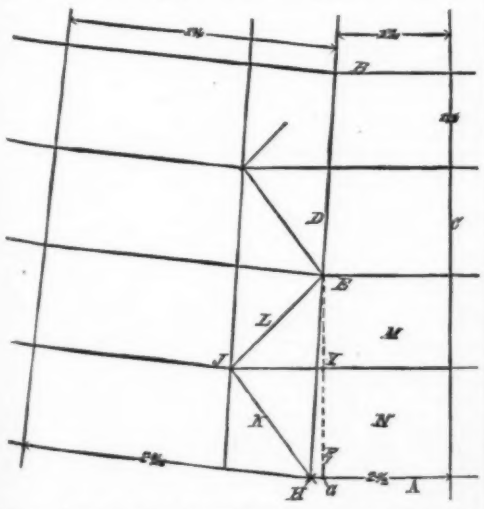


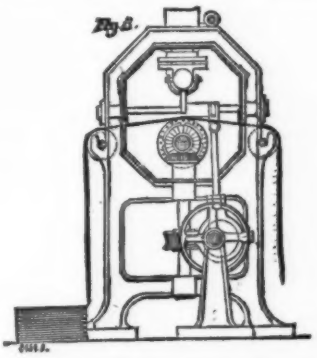
DIAGRAM D.—PLAN OF TRUNCATED CORNERS.

the large plans are cut out from this paper, they may be used as guides in the actual laying out of a bellows.

The broken sections are made in order that the corners should be clearly shown. It is only necessary to extend the lines according to the measurements given to have a full sized bellows.

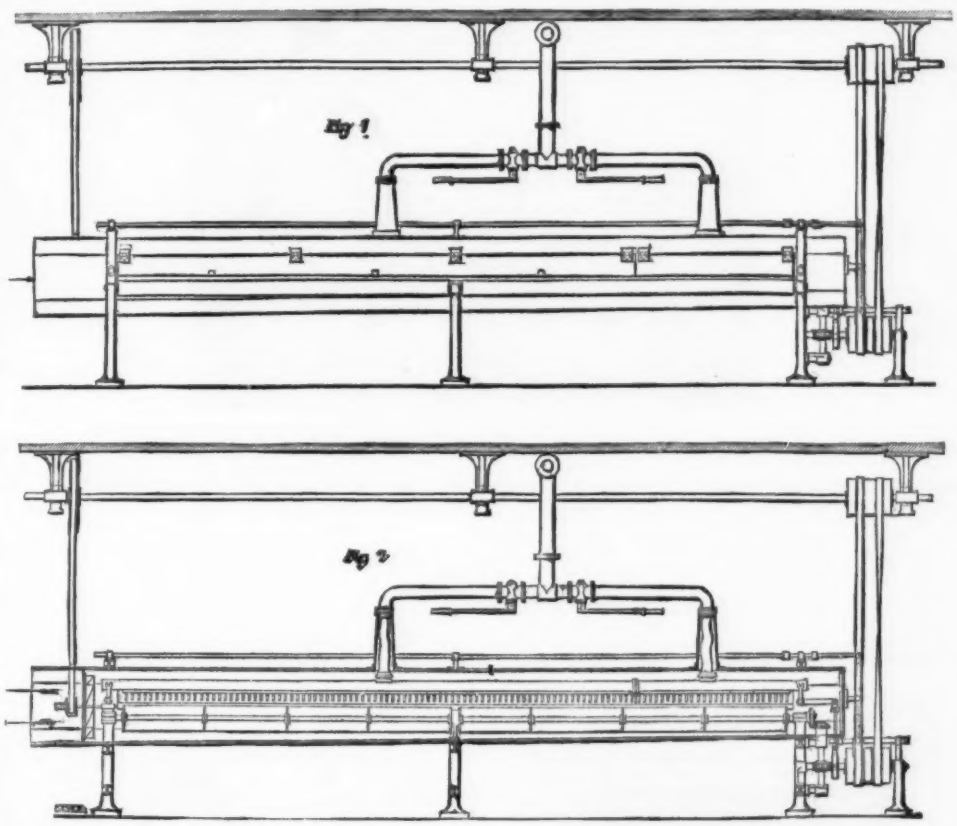
IMPROVED PNEUMATIC CARPET CLEANER.

THE accompanying engravings illustrate a machine for cleaning and removing dust from carpets and other similar fabrics by a novel process. Hitherto, when machinery has been used for this purpose, the system employed has merely been an amplification of the crude method of hand-beating, sticks, chains, straps, or ropes being used. Carpets submitted to this beating or "hammering" process are frequently torn and otherwise damaged; holes are enlarged, and worn, tender places are made into holes. In the process now illustrated all chance of damage is eliminated, as no form of beating whatever is resorted to, the cleansing being effected solely by the use of minute jets of compressed air driven at a pressure of 45 lb. to 50 lb. per square inch entirely through the fabric. These carry along with them every particle of dust from the carpet without any damage whatever. In the accompanying illustration Fig. 1 represents an outside elevation of the pneumatic carpet-cleaning machine, Fig. 2 a longitudinal section, and Fig. 3 an elevation at the driving end of the machine. From these it will be seen that nearly the whole of the machine is inclosed in a hexagonal casing provided at each side with swing doors for the insertion and withdrawal of the carpets. Compressed air is conveyed from the main pipe by means of the two flexible branch pipes to the longitudinal feeder pipe running the entire length of the machine. This pipe is fitted at intervals of 2 in. with a number of nozzles, each having a small hole at its nose, through



which the compressed air escapes in minute jets at great velocity, on to and through the carpet. This is carried slowly under the jets by the central wire roller, to which a rotary motion is given by the bevel wheels and driving pulleys shown. After the carpet has once been passed through the machine by the roller, if found desirable—as in the case of very thick carpets—it can be passed through a second time by reversing the action of the revolving roller. The feeder pipe carrying the nozzles rides at each end on trunnions, carried by an upright lever and shaft, to which an oscillating motion (of 2 in.) is given from the driving shaft by an eccentric and rod; the object of this oscillation is to thoroughly distribute the air currents over the entire surface of the carpets passing under it. This pipe is further divided into two unequal sections, from either of which the compressed air can be shut off when carpets narrower than the full width of the machine are being cleaned. The whole of the dust removed from the carpets, by the action of the compressed air thereon, is drawn away from the machine by an air propeller or exhaust fan at the left hand side of the machine; the dust being delivered into a chimney, flue, or other suitable receptacle.

By this method, carpets are cleaned so effectually that any amount of beating afterward fails to extract any dust, colors are revived, while the fabric sustains no injury whatever. Carpets of any description, cloth, and other similar materials can be similarly cleaned by this process, which is the invention of Messrs. T. & A. S. Warsop. A new plant for cleaning carpets under this process has recently been put down by the Manchester Pneumatic Carpet Cleaning Company, and is now in full and successful operation.—*Engineering.*



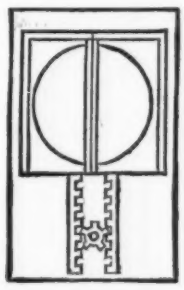
IMPROVED PNEUMATIC CARPET CLEANER.

A METHOD OF ILLUSTRATING COMBINATIONS OF COLORS.

A LENS 10 cm. in diameter and 15 cm. focus is cut in half, and the two halves are mounted in frames so as to be capable of sliding past each other precisely in the same way as the divided object glass of a heliometer. The motion is given by a pinon acting on racks in the same way as in the ordinary double-barreled air pump.

In the frames which carry the semi-lenses are cut grooves in which slips of colored glass, or gelatine, or cells of colored liquids may be placed; and the whole is fitted on the nose of the lantern in place of the usual objective, a diaphragm with round aperture about 3 cm. in diameter being put into the slide-holder.

Thus when the two semi-lenses are so placed as to have their principal axes coincident, they act as a single lens and form one image of the aperture on the



screen; but when they are moved past each other by turning the pinion, two disks of light are shown which can be separated entirely or made to overlap to any required extent. If, then, glasses or liquids of any given colors are placed in front of the semi-lenses, the compound color produced by their union can be easily shown, either simultaneously with the component tints or alone by accurately superposing the disks, thus avoiding any disturbing effect of the intrusion of other colors upon the eye.

It is in this way easy to show, taking four prominent colors, blue, green, yellow, and red, that blue + yellow = white; blue + red = purple; green + red = yellow, etc.

In place of colored liquids, which are "messy" and liable to change, I almost always use colored glasses, either singly or superposed (cobalt blue, for instance, cemented to "signal green" glass gives a good pure blue). Such glasses can by patient and careful selection be obtained of almost any required tint and intensity.—*H. G. Madan in Nature.*

PHYSICS WITHOUT APPARATUS.

IMITATION OF THUNDER.

AFTER asking a person to put his hands to his ears, pass a string around his head as shown in the accompanying engraving. If, now, you press the string lightly between your fingers, and gradually move your hand toward you, the person submitted to the experiment will hear a loud rumbling resembling thunder. In order to produce the desired effect well, a few precautions are necessary: Before the end of the string is reached, it is necessary to grasp the latter with the other hand at the starting point. Upon operating thus, it is possible to prolong the experiment for some time.

IMITATION OF THUNDER.

Upon placing the nails against the string, and removing the hand by jerks, sharp peals of thunder are produced that change into a distant rumbling through a slight separation of the nails. This experiment, as a general thing, does not fail to astonish those who are the objects of it. It cannot be imagined how intense an impression is produced upon the tympanum.

FIG. 1.—A NUT BROKEN BY THE FALL OF A KNIFE.

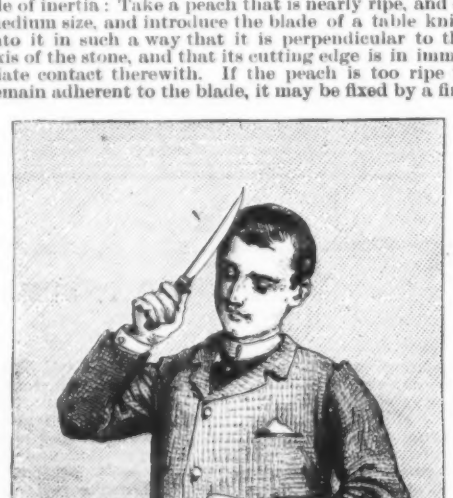
LAWS OF THE FALL OF BODIES.

Stick the point of a knife into the upper part of a door frame, so that, on striking the latter with the fist, the knife will drop to the floor. The question is to know exactly where the knife will fall. If a nut be placed at the place of fall, the knife, on dropping from a certain height, will break it. In order to find the exact spot, introduce the handle of the knife into a tumbler of water, so that when the glass is removed a drop of the liquid will separate from the handle. It will then only be necessary to place the nut at the point where the drop has fallen, and give the door frame a blow, when the knife will fall and certainly break the nut. Fig. 1 shows the mode of arranging things for the experiment.

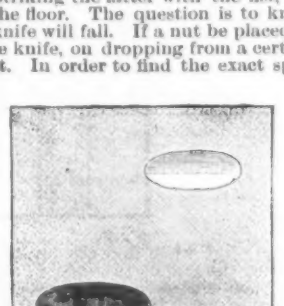
On another hand, take a cent and a piece of paper and cut the latter into the form of the coin. Placing these two objects alorgside of each other, let them fall. The coin will reach the floor much sooner than the paper. Now place the paper disk upon the upper surface of the coin, and let the latter fall in its horizontal position. The two objects will then reach the floor at the same instant, because the paper in contact with the cent has been preserved from the action of the air. The weight of bodies counts for nothing in their fall. It is the air alone that prevents them from falling with the same velocity.

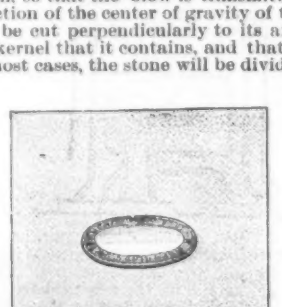
THE PRINCIPLE OF INERTIA.

The following is a curious experiment on the principle of inertia: Take a peach that is nearly ripe, and of medium size, and introduce the blade of a table knife into it in such a way that it is perpendicular to the axis of the stone, and that its cutting edge is in immediate contact therewith. If the peach is too ripe to remain adherent to the blade, it may be fixed by a fine thread; but the cutting edge must always remain in contact with the edge of the peach stone. The whole is held in the left hand through the extremity of the knife handle; then, by means of a knife like the other, held in the right hand, the back of the first knife is given a quick, hard blow in the vicinity of the fruit. If the knife has been properly introduced into the peach, so that the blow is transmitted sensibly in the direction of the center of gravity of the fruit, the stone will be cut perpendicularly to its axis, as will be also the kernel that it contains, and that too very sharply. In most cases, the stone will be divided obliquely; but the experiment is none the less interesting, considering the well known hardness of peach stones.



EXPERIMENT ON INERTIA.





FIGS 2 AND 3.—EXPERIMENT ON THE FALL OF BODIES.

It is well to operate over a table, and to make use of common knives whose backs there is no danger of damaging.—*La Nature.*

DR. BUISSON of Paris claims to cure hydrophobia by hot baths. He makes the patient remain continually in a hot room, and the baths are made as hot as 142°.

THE YUKON REGION.

FACTS ABOUT THE INTERIOR OF ALASKA.

A CORRESPONDENT of the Alaska *Free Press* writes the following interesting letter:

I left Juneau early last spring for the new El Dorado, the Yukon and its tributaries. I took passage to the portage per steamer Yukon, paying $10 fare and 50 cents per hundred lb. for my outfit. The latter consisted of six months' provisions, tools, blankets, etc., amounting in all to about 600 pounds. When I arrived at the portage, I experienced some difficulty with the Chilkat Indians in making the arrangements to pack my stuff over the range, but finally, after agreeing to pay $18 per hundred lb., and two dollars to the chief for the privilege of passing through his country, I succeeded in getting my outfit over. Two and one-half days were thus consumed in reaching Lake Lindenman. Here I loaded it on a sled, and hoisting a sail started over the frozen surface of the lake. I was lucky in having a good stern wind, and my sled moved before it about as fast as I could walk and guide it. After crossing and leaving the lake, I put myself in harness, and for nearly a week's travel his muleship tugged and strained and swore before his load until the open waters of the river were reached. Here I went to work whipsawing lumber from a very dwarfed growth of timber for the construction of a boat.

This consumed three days. When finished it was a substantial structure, but very unwieldy, but nevertheless answered all purposes. My first day on the river was nearly as hard a one as when I was pulling in the harness, on account of slush ice, which was running very thick, and my boat would get into a jam and the whole would become clogged in some eddy, where only with a great deal of labor it could be extricated. But I finally got the run of things, and putting well out into the middle of the stream, I found that my boat would float down rapidly with the ice, and then all I had to do was to steer clear of the larger jams. When it got too dark to run with safety, I pulled into shore and pitched camp for the night. Traveling this way, I reached the mouth of Stewart River, which is about 600 miles from Chilkoot, or the head of tidewater. Here I met a party of miners, who informed me that the big excitement was down on what was known as Forty Mile Creek, 40 miles below Fort Reliance, and that all the boys who had wintered on Stewart River, and also those who had come in that spring before me, had gone on down, and that they were also going to pull for that place shortly.

Being a stranger in the country, I could do nothing better than follow the excitement. So the following day one more boat was floating down the Yukon, its solitary occupant bound for the new discoveries.

The current was strong, and I was but a few days making the old fort. Here I rested a week, then, in company with three miners, who had arrived some days before me, and were bound for the same place, we started for the new camp. The mouth of the river, or Forty Mile Creek, was reached in one day and a half, being all down stream and a swift current. Here we found in the neighborhood of 25 men preparing to ascend the river, and we were informed that a number had already started up. This stream is a very large and swift one, and we readily perceived that it would be no small job to navigate it up stream, and that one man alone with his boat could not possibly make it.

I formed a partnership with one of the boys who accompanied me down from Fort Reliance, and together we started. But a few hours on the water told us that we had undertaken a big task, and that rowing up was out of the question, so we cut some long poles, and commenced poling up.

At times we would have to walk along the bank, one pulling on a rope attached to the boat, and the other with the pole pushing the boat off shore. The first day we covered about eight miles of the distance, when we pitched camp for supper and rest. Early next morning I struck up stream with pan and shovel in hand on a prospecting tour, and soon, finding a small gravel bar, I then and there washed out my first pan of dirt on the Yukon. And I was not a little surprised at the result. My first pan yielded fully four cents in medium coarse gold. I then began to look around and washed out several more pans of gravel, sometimes getting more and sometimes less, but I soon found that not enough of the bar was uncovered to pay us to stop there, and that a great deal of work would have to be done before any amount of gravel could be washed. So we again pulled up stream, where we had heard the gravel yielded as high as $2 to the pan in coarse gold. We poled, pulled, and prospected for a period of 14 days, when we struck a bar about 60 miles up from the mouth that we thought would pay us to camp with for a short time, at least. We staked off the 300 feet, as allowed by the miners' regulations, and set to work making a rocker. Meanwhile I had spent some time prospecting our little bonanza. I found we had a point of gravel exposed about 25×100 feet, and it panned all the way from three cents up to $1.75 to the pan. In one place just behind a big bowlder, I obtained as high as $6 to the pan, and in this were nuggets from 25 cents to $2.50 in value. Of course we rocked here first, but cleaned it out in three days, the two of us having rocked out in that time about $230.

Behind this bowlder we cleaned it out to frozen gravel, which resisted all efforts on our part to mine with pick and shovel. That there was plenty of pay in this frozen gravel I have not a doubt, as what we were able to pick out panned well. We then moved our rocker down to the lower end of the bar, where we commenced operations, taking the gravel from the water's edge first, and working it down until the water got too deep to be taken out any longer. In this way we worked it out about four feet back from the water's edge, where the frozen gravel came in. It yielded from $8 to $11 per day apiece, and when we could strike a bowlder, the gravel behind it would always be much richer, and we would take out much more, owing to the size of the bowlder and the amount of gravel behind it.

It took us 36 days to work out this bar back to the frozen gravel, and when we counted up we found that we had something over $500 apiece. We then moved our rocker up to the bowlder where we first commenced operations, thinking that by burning off the moss we could thaw out and work some of the gravel. The moss was quite dry on top and burned well down to a depth of several inches, but would not burn down the

entire depth to the gravel, which was about two feet. We found that we could not hope to accomplish anything in one season this way, and that we would either have to pick it out or hunt new diggings. So we again tackled it with the pick. We found that the sun since we had left it exposed had somewhat thawed out the face, and we picked out enough gravel to run the rocker for another day. But beyond this it was no go. It was as hard as a rock, and if there had been millions in that bank, we could not have done otherwise than leave it.

At any rate, the river was now beginning to come up, and in but a short time afterward our little bar was flooded. We then began to prospect for high bars that were more exposed to the sun, but our search was not successful. Nevertheless, we found plenty of gravel that would pay from one to six cents per pan, but they were too high to get water on to without some time and expense, and time during the washing season here is valuable. By this time the river had gone down again, and we then prospected for river bars.

We spent two weeks thusly, having gone up the river some 20 miles or more. We found good pay on every point of gravel; but we, like all the rest, were looking for big pay, and passed bars that would yield us from $7 to $10 per day. But that was no pay in the Yukon, although if we had gone right to work on them, and rocked steady, we would have done better than to have run around so much prospecting for big pay.

We finally struck a bar and set our rocker once again in motion. On this we had a strip of about 25 feet of exposed gravel in length, and near the center of the strip another bowlder. But the bowlder had a sharp nose up stream, and consequently not much room behind it in which gold could lodge. But the whole strip yielded fairly, and in 12 days we rocked out about $300 more. Here it was the same as before. About four feet back from running water the gravel was frozen, and we could not work it. It was now along about the last of July, and as my provisions were running short, I concluded I had better skip for the outside world. I did no more prospecting, and, although it was about the middle of the working season, I began making preparations to come out. Consequently, about the 1st of August, in company with quite a party, I started.

During this season spent on the Yukon, I never enjoyed better health in my life. Although I put in many a day of extremely hard labor, especially in poling up the streams, I can speak in loud praise of the climate on the Yukon. The assertion may to some seem to be a little overdrawn, but it is nevertheless a fact that the heat there during July is all but suffocating, and a bath in the river during the heat of the day was quite refreshing. The sun takes only about forty winks of sleep, or something like two or three hours during the longest days, and it is a great wonder to me that he has not succeeded better in melting down that frozen country, and no doubt would were it not for the thick carpet of moss that covers nearly the entire surface. A man going in, prepared to take advantage of all obstacles, can rock about four months out of twelve, and possibly more.

The mountain ranges of the interior are very high, the peaks running up like towers. I had been informed that to the west of Fort Reliance was a mountain peak to all appearances higher than Mount St. Elias, but no bearings or altitude had ever been taken of it. The peaks are clothed in perpetual snow.

As to the mining outlook of the Yukon country, with my limited explorations of it, I think that no other country on the globe has a better showing than it now has. That there is an abundance of gold there is beyond question, as was shown by the past season's mining on Forty Mile Creek. You have in a former issue stated that about $100,000 were taken out. Now as to the correctness of the statement I am not prepared to judge very accurately, but think it a little high. But I do know that if all who went in there had made as well as myself, a much larger amount than the above estimate would have been the season's output. Some took out considerably more than I did, then again others did nothing whatever. But this latter fact was not owing to the scarcity of gold or gravel bars, but rather to no work being done by them.

I have seen men throw down shovel and pan when they were making all the way from $6 to $25 per day, and strike out into the hills hunting, or on tours of observation of the country and prospecting for better pay. In fact, I myself have left $6 to $10 bars as though not worthy of consideration. But where does all the gold come from? is the question.

This season's explorations on Forty Mile Creek reached about 120 miles up from the mouth, and the gold was still continuous; and it was also found in paying quantities on several small tributaries putting into it. That the gold comes from quartz ledges is an established fact, for float quartz carrying free gold, and I might say gold-carrying quartz, is found along the streams. Steel's $32 nugget had quartz adhering to it, and I washed out a number of small nuggets composed of both gold and quartz. This season's prospecting has so far only shown up a few small stringers of quartz cutting through the slate formation, carrying no gold visible to the eye, and it would be ridiculous to say that they were the gold feeders. It undoubtedly has its origin in leads of quartz somewhere near the heads of these streams, and along the volcanic connection in the Alaskan range of mountains. On my journey down the Yukon, and in the near vicinity of Fort Reliance, I picked several chunks of rich copper ore, and in places in the rocky formation I noticed a great deal of copper stain, but did no prospecting for the leads.

A miner who goes in the early spring with only six months' provisions has but a few days to devote to prospecting, if he wishes to make his trip a profitable one. In fact, the distance to and from is so great that during a six months' trip the miner cannot possibly spend more than two months mining and prospecting, the other four being spent on the road, and it is rather discouraging than otherwise to most who go in. Unless men grasp the situation in a practical way, and go in prepared to stay a year or more, the development of the country will be slow and the output small.

As before stated, I left the Forty Mile Creek diggings about August 1st. The route back is more difficult than going in, for the simple reason that going in you have it down stream all the way, and coming out it is all up stream, and against a swift current too. Your boat has to be towed and poled up stream something like 600 miles, and about 35 miles of the route you convert yourself into a pack mule and pack on your own back all your effects, and over a high, steep range, too.

But, notwithstanding, I hope very soon to see a practicable route opened up to that section, a pack train running over the range on this end of the line and steamboats on the rivers on the other end, and provision stores scattered throughout. When this is accomplished, the Yukon country will prove herself to be the richest gold producer in the world.

ALASKA GRAVEL MINING.

It is remarkable, indeed, that so much of the surface ground on the Yukon is frozen solid to a depth of several feet. It is all the more so when we come to realize the fact that during the summer it gets as hot there as in the South. During the heat of the past season, the miners found it a great convenience to go in bathing in the streams at least twice a day, and to seek shady places in which to rock the gold out of the gravel. At the breaking up of winter, the hours of sunshine are rapidly increasing, and continue so until midsummer, when the sun beams forth 22 hours out of the 24, while on the high mountain peaks it is for a period of several days in June not entirely out of sight during the 24 hours. But during all this heat and long days of continuous sunshine, the sun's rays do not penetrate the heavy mosses that cover nearly the entire surface of the country, and consequently the frozen ground underneath lies in that state as if packed in an icehouse. After it once becomes frozen, as any damp ground will do in the winter time, it quickly becomes covered with this moss, which is of a remarkably rapid growth and attains a depth of some two feet or more. During the heat of summer, this moss becomes dry to the depth of several inches, and the miners think that by a continuous burning of it as fast as it dries, they will soon have the gravel bars along the creeks, at least, cleared off, being of the impression that when the gravel deposits are exposed to the scorching rays of the sun, and rains and atmosphere, they will readily thaw out. When winter sets in, the hours of sunshine gradually decrease, until, during the shortest days, the sun shines but four hours out of the 24. But at this period the aurora is most intense, and helps very materially in driving darkness from that dreary land. The thermometer goes down to —70° in winter, but the atmosphere is very dry, and consequently the cold is not so perceptible as one would imagine.

LIGHTNING.

THUNDER storms are, as is well known, much more frequent in summer than in winter. Statistics recently collected in France show that during the three hot months of summer, lightning strokes, whether to animals, trees, or buildings, are by far the most frequent; while during the winter months there are few or none. The cause of this is not very apparent; but a German writer has attempted to show, from observation and experiment, that electricity is generated by the friction of water vapor in the atmosphere; the vapor being raised up by the sun's heat. Friction of water particles has been known to generate electricity since the days of Armstrong's electrical machine, in which a jet of steam escaping from a narrow pipe is found to be electrified. The mere evaporation of water may or may not give rise to electricity; the question is at least a doubtful one; but the effect of rubbing of water particles against a mouthpiece is undoubted. There is also reason to believe that the particles striking against each other, or the atoms of the air, also give rise to electricity. The vapor thus charged condenses into floating masses which we term thunder clouds.

Now, as a charge of electricity has the property of inducing another charge of electricity of an opposite kind to itself on any "conducting" matter near it, and as the earth is composed of what is called conducting matter, it follows that a charged cloud sailing over the surface of the earth induces an opposite charge on the ground below.

These two opposite charges, one of "positive" the other of "negative" electricity, tend, by another well-known property of electricity, to rush toward each other and combine. Hence when they are able to overcome the resistance of the air between, which keeps them apart, they leap together with a flash and crack, producing the familiar phenomena of thunder and lightning.

It is the old story of the electric spark. When a rod of dry sealing wax is rubbed with the warm hand or a silk handkerchief, it becomes electrified, and if it is then held near a piece of metal, a tiny spark accompanied by a faint snapping sound will be observed. In this experiment the sealing wax corresponds to the cloud and the metal to the earth, and the spark which passes between them is the lightning.

Sometimes another cloud floating near the first one takes the place of the earth, and then the lightning flash takes place between them. Lightning of this kind does not strike the earth; but it might have a destructive effect on the latter for all that, because it might give rise to the "back stroke," which is sometimes fatal to life.

The "back stroke" is not due to the direct flash and discharge. It is rather the reaction after the direct discharge has taken place elsewhere. Suppose, for example, that a tract of upland country, a rural district with trees, farms, and here and there a church dotting it, is covered by a thunder cloud, which induces a charge of electricity upon it. In order that the charge upon the earth may get nearer to that upon the cloud, so as to combine with it, the electricity, by another well-known property, will heap itself on the most prominent and pointed objects of the landscape. That is to say, it will accumulate on the trees, barns, chimney tops, and spires of the district.

The whole atmosphere of the region is in a state of tension and suspense. The bolt is trembling in the balance, but no man knows where it will fall. Presently there is a blinding flash of light, the sky is rent with a lurid stream of fire, and instantly the tension is relieved. The discharge has taken place at one point, the point which offers the path of least resistance through the air, and at which the electric tension was most critical. At every other place where the electricity had seriously accumulated, there is consequently a sudden fall of electric potential, or a collapse to its old condition, or, as it is called, a "return stroke." This instantaneous change is sometimes as fatal as the direct discharge, and it may ruin a building or destroy life several miles from the scene of the flash. The direct stroke is therefore more mysterious and unexpected than the flash, but fatal effects are comparatively rare from it. Nevertheless, since the latter have been attributed to this cause, a person cannot feel quite safe, although a thunder storm with lightning is still several miles from him; the number of miles being estimated by counting the seconds which elapse between the flash and the peal, and allowing a distance of four miles for every second counted. He may feel safer than if it were close upon him, but there is still some room for fear.

In fact, there is no real safety except within the area properly protected by a lightning conductor, or in a building which is itself a protector, for instance a sheet iron house. Every building, then, should be protected in order to be safe. In the country, where these are often isolated, a lightning rod would be required for each; but in towns one rod would sometimes protect more than one house around it, according to its height and conductivity. Lightning rods, as they are now made of copper, are so expensive that most people prefer to trust their chances of escaping a discharge than have their homes protected. Yet a change of feeling in this respect will probably come about in course of time, especially if lighting rods can be had, as they are likely to be, for a trifling sum. It is important, however, that the rod should be properly planted with a good "earth" connection, and properly run up above the chimney with pointed ends into the air. Although the rod may be a simple affair, for example, two or three twisted lengths of telegraph wire, it should only be applied to the building by a person skilled in the work, or else it may invite instead of warding off destruction.

Thus bare electric light and telegraph wires running on poles in the open air have sometimes been taken into buildings carelessly, and by providing a path of less resistance for the lightning to "earth," have brought the discharge down upon the roof of the building. The effect may be more forcibly realized by conceiving a person to carefully plant the bottom of his lightning rod in connection with the earth and then take the other end indoors, instead of running it outside the house until it cleared the roof.

The flash takes place at the point of least resistance, because it is here that the two opposite electricities can easiest rush together. But the eagerness with which they tend to rush together is another thing to be considered. These two things taken together determine the discharge. There may be less resistance to the flash at one house or tree than at another, but if the attraction between the opposite electricities is less at the former, the flash may traverse the latter house. Hence one cannot exactly say if one tree or building will be safer than another. There is great uncertainty, and this is a reason for the instinct of awe and uneasiness which most animals feel on the approach of a thunder storm.

In general, however, we can say that high houses, or those perched on high ground, are more likely to suffer from the discharge than small, low-lying houses. The former are therefore all the more eligible for protection; and they are to be avoided in seeking shelter from a storm. So are houses surrounded by trees, and with ponds or pools of water close beside them. For trees act as imperfect lightning rods, having a good earth connection, and especially if they are wet the discharge may strike the house in order to reach the ground through them, or, in the case of the pond, through the water. One should not shelter under trees of any kind, but more especially tall, soft trees like poplars. Many deaths have been incurred from sheltering under poplar trees in France.

Thunder storms are said to be more frequent in open, treeless countries, such as the Transvaal or the Scottish hills, and the fact has been attributed to the unchecked ascent of electrified vapors; but on the other hand they are probably less destructive in such countries. One fatal accident a few years ago may be remembered by many, that is, the death of Lord Lauderdale, who was killed by the discharge while out grouse shooting. The discharge entered his forehead, and after emerging at his breast left the marks of its passage in two streams down the left leg. The brain and spinal cord being of nervous matter are better conductors than other parts of the body, and hence are not disturbed to the same degree as the latter. The flesh is sometimes rendered livid, and at others quite charred. Curious pink prints, as of arteries and trees, are sometimes left on the skin by the fluid; and watches are fused, clothes singed, and boots torn into shreds or pierced through, as happened in the case of Lord Lauderdale. Often death is quite painless, since it occurs before the brain has time to feel; but at other times, as in the Lauderdale instance, it is accompanied by intense suffering. Those who are not killed outright, and recover their senses, tell of feeling a heavy blow when the shock came, and the disintegrated and disordered system occasions them severe pain.

Chimneys, by creating currents of warm smoke, and by their lining of conducting soot, are dangerous parts of houses, and there are many instances of the discharge taking that road. It were better then to avoid sitting near a fire in a storm. Indeed the safest place in the house on such an occasion would seem to be in the cellar and basement rooms, or upon an iron bedstead. In the open air, there cannot be a safer place than a dry hole or ditch, for it places the body below the surface of the ground, and therefore not exposed on a prominent place. But it should be a dry hollow, else the water in it may invite the discharge; for water being a conductor in good connection with the earth, lowers the resistance to the discharge.

Fire balls are the comedy of lightning, and play the "antic" part. Many singular feats are recorded of them, such as quietly floating down a chimney, and after astonishing the inmates of the room, suddenly disappearing up the chimney with a flash and bang. They are frequently witnessed, and a flash of lightning was seen during the past summer from Westminster Bridge to throw out fire balls like Roman candles. Nevertheless, the true nature of fire balls is not at all well known. M. Plante has shown by experiment that they are perhaps the luminous end of a gentle discharge of current electricity passing between a charged cloud and the earth. Both observations and experi-

ments are, however, still required to explain these mysterious vagaries.

Of late years new light has been shed upon the phenomena of thunder storms; and there are signs of a more systematic study of their effects being instituted. Professor Schuster's recent discovery that air is comparatively speaking a conductor of electricity, provided it be "polarized" by the passage of another electric discharge, has an important bearing on this subject, and helps to explain the length of some lightning strokes. The experiments of Threllfal on the production of ozone by electric discharges in air confirms the common belief that lightning freshens the atmosphere; and the results of experiments in depositing dust and vapors by statical discharges from a Wimshurst machine also strengthen the popular faith in lightning as a purifier of the air. In fact, the "smuts" frequently observed when the atmosphere is dull and "thundery" may be a similar effect to what he has observed. Again, the experiments of Professor Hughes on self-induction lead to the conclusion that the best form of lightning rod is a flat ribbon of copper or a strand rope of copper or iron, since it has less self-induction than a round rod or wire.

It has also become clear that in order to insure protection by lightning rods they should be periodically tested by a competent person; and Messrs. Siemens and others now supply apparatus for this purpose, together with the separate insulated wire to the lightning rod which is necessary to complete the testing circuit. By this means the conductivity of the rod can be ascertained from time to time. Indeed, it is becoming more and more evident that lightning rods should only be erected by skilled electricians knowing the business thoroughly, and there is some reason to think that the board of trade, or at least the insurance companies, should provide that lightning rods be erected in conformity with the conditions laid down by the lightning rod committee, or to speak more correctly, in accordance with the latest results of electrical science.

France has for some time past instituted observations on, and collected statistics of, lightning strokes. Germany has established observatories for studying the same phenomena, and at the recent meeting of the British Association at Manchester the Hon. R. Abercromby proposed a plan for the systematic study of thunder storms. It will thus be seen that combined action is being brought to bear on this important subject. Already the Germans have discovered that low, marshy lands and inlets of the sea are more frequently visited by lightning than dry uplands. There is much, however, to be found out, and the subject, besides having a peculiar interest, is both profitable and humane.—*Engineering.*

SYNTHESIS OF A SUGAR.

THE announcement from Wurzburg that Professor Fischer and Herr Tafel have succeeded in preparing artificially a compound possessing the properties and having the composition of a true sugar—in fact, differing from glucose chiefly, if not entirely, in its behavior toward polarized light—marks another important advance in the progress of organic chemistry. This synthesis is the outcome of a long series of researches which have been laid before the Berlin Chemical Society and recorded in the *Berichte*, but its attainment probably first came within the range of perceptible possibilities during an investigation of the conditions attending the oxidation of polyatomic alcohols. Previously to this subject being taken up by Messrs. Fischer and Tafel, the products obtained as the result of such oxidation had, with one exception, been acids, the probability being that the aldehydes or ketones first formed escaped observation through lack of suitable methods for their separation. The exception, mannite, yielded to Gorup-Besanez a sugar that was named mannitose, but which has since been proved, by its behavior toward phenylhydrazin, to be identical with lævulose. In consequence of this result, Messrs. Fischer and Tafel experimented upon other polyatomic alcohols; glycerine, erythrite, and dulcite being oxidized with nitric acid, and phenylhydrazin being used for the detection of the aldehyde or ketone. This was an application of an observation made previously by Professor Fischer, that the varieties of sugar which reduce alkaline copper solution form with phenylhydrazin crystalline compounds difficultly soluble in water and therefore easily isolated. The manner of formation of these compounds is represented by the following equation:

$$C_6H_{12}O_6+2C_6H_5.N_2H_3=C_{1\cdot}H_{22}N_4O_4+2H_2O+2H.$$

Each of the three products of oxidation mentioned yielded a hydrazine derivative which corresponded in composition, manner of formation, and properties to compounds of phenylhydrazin with sugars. Glycerine, especially, yielded a beautiful crystalline product, having the composition $C_{18}H_{16}N_2O$, which seemed to have been formed, in all probability, from glycerine aldehyde ($CH_2OH.CHOH.COH$) or the isomeric ketone ($CH_2OH.CO.CH_2OH$), though it was not possible to isolate the aldehyde. It may be convenient to mention here that the term "phenylglycerosazon" has been applied to the glycerine derivative, the term being modified when applied specially to other derivatives, so as to indicate the origin of the compound.

In order to study more closely the origin of this glycerine compound, it was determined to attempt to prepare glycerine aldehyde another way. To effect this, acrolein was treated with bromine to form bibromacrolein, which was found to be easily attacked by baryta water, with the result that the bromine was replaced by hydroxyl radicals, the product being a very soluble substance that energetically reduced Fehling's solution, and possessed all the properties of an aldehyde alcohol. It having been suspected that a sugar might be formed in this way, a preliminary attempt was made to isolate such a product, if it existed, by means of phenylhydrazin, and this was so far successful that a substance of the osazon class was obtained, having the composition $C_{15}H_{22}N_4O_4$, and scarcely distinguishable from phenylglucosazon, the compound formed by glucose with the same reagent, except in being optically inactive. This result, at least, left little doubt that a sugar had been formed from the bibromacrolein under the influence of the baryta, and probably according to the following equation:

$$2C_3H_4Br_2O+2Ba(OH)_2=C_6H_{12}O_6+2BaBr_2.$$

The next difficulty, therefore, to be overcome was to regenerate the sugar from the hydrazin compound, to which the name "phenylacrosazon" has been given to indicate its origin from acrolein. It was then found, in the course of purifying the substance resulting from the combination of phenylhydrazin with the products of the decomposition of bibromacrolein, that two isomeric compounds were present, one of them insoluble in ether, the other soluble in the presence of resinous impurities, but nearly insoluble when pure, and these were designated respectively α-phenylacrosazon and β-phenylacrosazon. Some of the α-phenylacrosazon, which was the preponderant constituent, was submitted to the action of reducing agents, resulting in the formation of a base which, when analyzed as an oxalate, gave figures corresponding to the formula $(C_6H_{13}NO_5)_2$ $C_2H_2O_4$. This base gave all the reactions of glucosamine; it reduced Fehling's solution vigorously when warmed, but it was optically inactive. The neutral oxalate dissolved in ice-cold water was then treated with a calculated quantity of sodium nitrite and a little oxalic acid, which caused the evolution of all the nitrogen from the base. After this reaction had finished, the liquid was exactly neutralized with soda solution, evaporated in a vacuum, and the residue extracted with alcohol, which left upon evaporation a sugar in the form of a light brown sirup, free from nitrogen or ash, having a sweet taste, reducing Fehling's solution very strongly, and combining with phenylhydrazin to reproduce phenylacrosazon. It has not yet been ascertained with certainty whether it is fermentable. In fact, the only point of difference yet observed between it and a natural sugar is that it is perfectly inactive toward polarized light.—*Pharm. Journal.*

ALKALOID-LIKE BASES IN PARAFFIN OIL.

WELLER has called attention to the occurrence of basic bodies resembling the alkaloids in a yellow paraffin oil of sp. gr. 0·850 to 0·860, obtained as a by-product in the Saxony paraffin works. To obtain these bases 500 kilogrammes of this paraffin oil were agitated with dilute sulphuric acid, the acid decanted, mixed with soda solution, and agitated with ether; the operation being several times repeated. A dark brown oily residue was left after distilling off the ether, which gave, on distillation in a current of steam, a colorless oil of 0·89 to 0·99 specific gravity and having an intense disagreeable odor, mouldy when cold and recalling pyridine when heated. This oil contained nitrogen, but neither sulphur nor oxygen, and distilled unchanged between 220° and 260°. Ammonium oxalate precipitates its solution in hydrogen chloride, the precipitate being white and crystalline. By saturating an alcoholic solution of the bases with oxalic acid, the oxalate is obtained first in fine needles, which rapidly increase to large plates, extending through the solution. After recrystallization, the crystals are pearly in luster and have a fatty feel, and are soluble in hot water.—*Ber. Berl. Chem. Ges.; Jour. Sci.*

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